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ERRATA

Page	Line	
23	28	*for* petriole *read* petiole.
30	13	*for* auxillary *read* axillary.
32	35	*for* cordiaceous *read* coriaceous
39	17	*insert* var. *conjunctum after elatum.*
43	31	*insert* contigentibus, cylindricis, apicibus *after* utrinque.
45	40	*insert* μ *after* 13.
46	1	*for* CRISPUN *read* CRISPUM.
56	24	*for Guadrum read Quadrum.*
56	38	*for* pyenoidibus *read* pyrenoidibus; *for* utroque *read* utraque.
56	43	*for subauriculata read subauriculatum.*
57	15	*for* psecies *read* species.
57	20	*insert* var. *conjunctum* (Turn.) W. et G. S. West *after* Borge.
58	33	*insert* var. CONJUNCTUM (Turn.) W. et G. S. West *after* Borge.
58	34	*for* ×890 *read* ×550.
89	16	*for* cotrol *read* control.
90	1	*for* hydroysis *read* hydrolysis.
93	4	*for* drv *read* dry.
105	Fig. 1-A.	*for* 2mm. *read* 2cm.
109	52	*for shamaedaphne read chamaedaphne.*
114	39	*for* semicicular *read* semicircular.
115	5	*for* semicicular *read* semicircular.
120	33	*for* wih *read* with.
123	38	*for* SHAMAEDAPHNE *read* CHAMAEDAPHNE.
161	22	*for Gloeocapsa read Pleurocapsa.*
162	6	*for Cladophoae read Cladophorae.*
162	22	*for* 1933 *read* 1833.
163	8	*for* 1943 *read* 1843.
165	15	*for* filamentorun *read* filamentorum.
172	15	*for* 1923 *read* 1823.
172	27	*for* 1842 *read* 1843.
174	24	*insert* μ *after* 6-7.
178	16	*for* pinnatificd *read* pinnatifid.
188	39	*for* 3, 5 (3): *read* 3, 3:
190	41	*for* silique *read* silicle.
193	15	*for* 3, 5 (4): *read* 3, 4:
204	30	*for* epidemis *read* epidermis.
204	31	*for* paralled *read* parallel.
211	25	*for* direcct *read* direct.

THE EARLY EMBRYOGENY OF GLYPTOSTROBUS

F. H. Wang

The genus *Glyptostrobus* is monotypic and it is endemic to South China. Its distribution has been generally recorded in two regions: the alluvial plain of Pearl River delta of Kwangtung and that of Min-kiang delta of Fukien. However, more recent explorations extend its range of distribution further north to Kiangsi. Hu (11) encountered its existence in the southern part of Kiangsi. Its occurrence in Ch'ien-shan-hsien (28° 09″, N.L.), eastern Kiangsi, is described by Chen (7). The specimens collected in Ch'ien-nan-hsien (24° 44″, N.L.), southern Kiangsi, are found at the herbarium of National Chiang Kai-shek University, Nan-ch'ang, Kiangsi. The specimens of *Glyptostrobus* collected from Kwangtung and Fukien provinces are deposited at the Herbarium of Academia Sinica, Shanghai, but not those from Kiangsi province.

Glyptostrobus is often planted near ponds, along river sides, and also dykes and borders of rice fields. Its swampy habitat is similar to that of *Taxodium*. Chun (8) studies the ecological aspects of *Glyptostrobus* based upon her observations and experiments. However, her treatment of the morphology is only limited to those of taxonomic characters. No work has ever been done on the developmental morphology of *Glyptostrobus*. The author is undertaking the investigations on the morphology and life history of this plant. The present paper considers the early embryogeny of *Glyptostrobus pensilis* and this is the first article of this series.

MATERIAL AND METHODS

The material for this investigation was obtained from two sources. Through the kindness of Mr. H. W. Mak of Kwangtung Provincial College of Letters and Science, arrangements were made for the collections of ovules in the vicinity of Canton at weekly or fortnightly intervals since March of 1947. The fresh ovules were killed and fixed there in Bouin-Hollande's (13) fluid as well as formalin-acetic-alcohol and they were sent to Shanghai by air mail. When dissected, ovules in the collection of June 10 were found in the early stages of embryo development and about two dozens of ovules, in which the prosuspensors had not yet elongated, were preserved for making paraffin sections. The ovules collected before June 10 were not included in the present paper. The rest of the material of embryos was collected by Mr. T. H. Ho who took a special trip under difficult circumstances in the summer of 1947. The fixatives used were formalin-acetic-alcohol and modified Navashin's solution. Collections were made at interval of three days from June 25 to July 19, 1947, also near Canton.

The ovules which were killed and fixed in Navashin's solution were found to be very satisfactory for dissection since the embryo systems were easily poured out without any difficulty. When formalin-acetic-alcohol was used as fixative many endosperm cells were always found adhered to the embryo complex and made the dissection difficult. Since most of the material was fixed in formalin-acetic-alcohol a special method was designed in removing the endosperm cells from the embryo complex. For this purpose Chinese writing brush was found to be very effective. Though the procedure was

rather tedious several hundred embryo complexes which were free from the endosperm cells were obtained in this way.

Buchholz (3) method of dissection and making total mount of embryos was generally followed. The embryos stained with erythrosine were not satisfactory. For better preparations the method of iron-alum Haematoxylin as described elsewhere by the author (15) was applied. The wall of the prosuspensors was stained bluish without obscuring the nucleus. Foster's (10) safranin and tannic acid-ferric chloride was also found to be satisfactory for staining the cell wall of the prosuspensor. The embryos were dehydrated with glycerine and mounted totally in the sandarac medium.

The sectioned slides were prepared for the period during fertilization and proembryo formation. Some ovules in the later stages were also sectioned for comparative study. The sections were cut at the thickness of 8-10 microns. All the drawings were made with a camera lucida.

OBSERVATIONS

Fertilization and proembryo formation—Fertilization was observed in the material collected on the tenth of June, 1947. However, the time of fertilization might begin several days earlier since most of the ovules in the same collection contained proembryos and also young embryos with the prosuspensor elongated and twisted.

The process of fertilization and proembryo formation is not completely known, since the material during this period of development contained but a few cones collected on June 10th, 1947 and all the ovules were found sterile in the previous collection ten days earlier. The following descriptions are, therefore, based upon the observations of the prepared slides from about two dozens of ovules as available.

The fusion of the male and the female nuclei takes place in the middle of the archegonium which is long and narrow. Figure 1 shows the first stage of the fusion. The female nucleus, which is ovoid, is a little larger in size than the male nucleus. Here their contact surface becomes compressed but their nuclear membranes are still intact. Then the male and the female nuclei begin to coalesce and their nucleoli attain their maximum size. This is shown in figure 2, in which the nuclear membranes of the male and the female nuclei along their contact surface have been dissolved. The fusing nuclei are ensheathed with a layer of starch grains (figs. 1 and 2). They move down to the lower part of the archegonium and the trace of the passage of the male nucleus from the upper part is still recognizable in figure 2. The first division of the fertilized egg has not been observed.

A second division follows, giving rise to four free nuclei. Figure 3 shows the free nuclei passing down to the base of the archegonium where they lie in a tetrad-fashion. Each of them still contains a prominent nucleolus. These nuclei divide again and eight free nuclei are formed (fig. 4). There is a gap here in the material that is available so that the arrangement of these free nuclei into two tiers and the origin of walls among them have not been observed. The next stage observed, figure 5, has the walled cells in the proembryo arranged in three definite tiers: the upper tier which is exposed to the cytoplasm of the egg, the middle tier which constitutes the prosuspensor and the lower tier which contributes to the embryo propers in further development. Six nuclei in the open tier, six cells in the prosuspensor tier and four cells in the lower

tier were found from the serial sections. These numbers agree with those of the proembryo of *Taxodium* as described by Coker (9). Since only two proembryos in this stage have been observed and the number of prosuspensor cells obtained from the later stages varied from four, five to six, it seems that this is not the typical one as represented in figure 5. Figure 6 contains four cells (only two cells shown) in each tier and this is probably the more common arrangement in *Glyptostrobus*. However, the origin of the odd number of five prosuspensor cells is still unexplained. The answer has to be waited until the later stages of the proembryo formation are actually observed.

Early embryogeny.—The first step in the development of the embryo begins in the middle tier, the prosuspensor. Figure 6 shows the prosuspensor cells becoming vacuolated in the upper part. The elongation of the prosuspensor pushes the embryo initials at their end down into the tissue of the female gametophyte. While the nuclei in the open tier are on their way to disintegrate (fig. 6). Figure 7 shows three embryo systems in a later stage dissected from an ovule. The one in the middle has its prosuspensor cells becoming embryonic by internal cell proliferation and the terminal embryo initials being suppressed in normal development. The greater rate of elongation of the prosuspensor than that of the corrosion in the female gametophyte results in the winding and coiling of the prosuspensor. This is shown in figure 8. The elongation of the prosuspensor lasts for some time. During this period the embryo initia's remain inactive at the tip of the prosuspensor.

The prosuspensor cells in the embryo system of normal development generally remain together before the multicellular embryo units develop at their tip. However, the prosuspensor cells in the embryo systems in an embryo complex may separate from each other during the early stages and they become the isolated prosuspensor cells. Such isolated prosuspensor cells may elongate considerably and collapse completely. Occasionally the embryo initials at the ends of the isolated prosuspensor cells may give rise to multicellular embryos, but it is more common to see that the prosuspensor cells which separate during the early stages lose the contact with the embryo units at their tips. This is shown in figure 9 in which six prosuspensor cells, probably from one fertilized egg, become isolated and left behind, while the two normal embryo systems have the prosuspensor cells remain together. The isolated prosuspensor cells are further shown in figs. 17 and 24 in later stages. It is of interest to notice here that the competition between the embryo systems is rather keen and only those embryo systems that survived through embryonic selection may proceed in the normal course of development. It is evident that only a few embryos are developed in an embryo complex since many prosuspensor cells become separated and collapsed before their embryo initials have a chance to develop into the multicellular embryos.

In addition to the deviation from the normal development of embryo systems by means of separation and isolation, further decrease in the number of normal embryos developed into the multicellular embryos is due to two other reasons. The first case is due to the abnormal prosuspensor cell or cells which become embryonic by internal cell proliferation. At first, the prosuspensor cells become dense in cytoplasm and then divide internally. Such prosuspensor cells are naturally checked in cell elongation and the embryo initials at their ends are suppressed (fig. 21). Figure 7 shows the prosuspensor cells of one embryo system in the middle become embryonic at an early

stage. Sometimes the prosuspensor cells of more than one embryo systems may become embryonic. Figure 21 represents an extreme case in which all the prosuspensors of three embryo systems in an embryo complex become multicellular internally. These deformed embryos, if we call them embryos, as derived from the division of the prosuspensor cells, do not advance very far in development. Buchholz (2, 6) illustrates such misshapen embryos derived from the prosuspensor cells also in *Cryptomeria* and *Cunninghamia*. The present author has not found such embryos beyond the stage shown in figure 22. The other abnormality in the development of the prosuspensor is the balloon-like formation and the development of the side lobes. This also suppresses the normal development of the terminal embryos at the tips of the prosuspensor. Figure 10 shows a rare case in which the prosuspensor cells of the three out of four embryo systems in an embryo complex form balloons and side lobes. All these deviations from the normal development of the prosuspensors necessarily deprive the normal development of the embryo units. It is, therefore, safe to say that the selection of the embryo systems in a given complex is predominent during the period before the embryo initials at the tips of the prosuspensor become active.

The observed numbers of embryo systems per complex ranged from one to six. A sample distribution of numbers of embryo systems for 200 complexes counted at random is tabulated in table 1. And of these 200 complexes counted, the distribution of numbers and their percentages of normal and abnormal embryo systems is also furnished in table 2.

TABLE 1. DISTRIBUTION OF NUMBER PER EMBRYO COMPLEX FOR 200 OVULES

No. of embryo systems	1	2	3	4	5	6	Total	Mean
Frequency	33	71	52	33	7	4	200	$2.61 \pm .082$ δ 1.16

δ = standard deviation

TABLE 2. DISTRIBUTION OF NUMBER OF NORMAL AND ABNORMAL EMBRYO SYSTEMS IN 200 OVULES

No. of embryo systems		1	2	3	4	5	6	Total	%
Cases of normal systems		154	28	6	4			192	36.8
Cases of abnormal systems	Prosuspensors isolated	64	118	72	32	10	12	308	59
	Prosuspensors embryonic and other abnormalities	10	6	6				22	4.2

From analysis of the data in tables 1 and 2 the following conclusions are drawn:

1. The number of the embryo systems developed from different fertilized eggs per embryo complex varies from one to six with the mean $2.61 \pm .082$ and the standard deviation 1.16.

2. Generally only one, rarely two, embryo systems develop normally in a complex.

3. About 59 per cent of the embryo systems form isolated prosuspensor cells which usually lose the contact with the embryo units at their end and collapse.

4. About 4.2 per cent of the embryo systems develop abnormally in which the prosuspensor cells become embryonic by cell proliferation as well as other abnormal ways of growth.

5. Only 36.8 per cent of the total embryo systems develops normally.

Returning to the normal development of the embryo, the embryo initials or embryo units at the prosuspensor tip become active when the prosuspensor elongates considerably. They are always four in number (figs. 11 and 12). In case the prosuspensor cells are more than four, the supernumerary cell or cells usually become detached at any position. In rare cases five prosuspensor cells are seen associated with four embryo initials at their tip. Figure 11 shows the prosuspensor tips of two normal embryo systems. Here the four embryo initials still remain undivided in the embryo system below, while one of four embryo initials in the embryo system above has already divided into two daughter cells of unequal size and the transverse wall is forming in the embryo initial at the left. The embryo initials situated underneath are drawn separately by the side of the embryo system since it is impossible to show them in the same drawing. Figure 13 shows two of four embryo initials from a sectioned preparation in which the one at the left is in the metaphase of cell division and the one at right is at 2-celled stage. The wall formed in the first division is usually transverse (figs. 11, 16, and 18), not infrequently inclined (figs. 12 and 13), and rarely vertical as shown in fig. 19. Coker (9) reported that the first wall is almost always inclined and produces two cells of generally unequal size in *Taxodium*. Buchholz (1, 4, 3) found it nearly vertical in *Sciadopitys,* almost always vertical in *Sequoia sempervirens, Sequoia gigantea* and also in *Cryptomeria japonica.* While Sugihara (14) found the first wall in the embryo cell of *Cunninghamia lanceolata* is usually transverse. It seems *Glyptostrobus* may represent a tendency from vertical to inclined and transverse wall formation in the first division of the embryo initial. Probably there is no significant difference whether the first wall is vertical or transverse since it varies in different ways. The resulting cells are surely of unequal size when the wall is transverse or inclined. While the daughter cells may be either of unequal size or of nearly equal size when the wall is vertically placed.

Each embryo initial at the prosuspensor tip develops independently of the others, even when they are near together. As a result different stages of development are found in the embryos from the same fertilized egg, as illustrated in a number of drawings (figs. 11-16; 18-19; 23-25; and 28). This agrees with the condition in *Taxodium* as described by Coker (9). Figure 14A shows both embryos at the 3-celled stage, while figure 14B shows two embryos at 4- and 5-celled stages from the same prosuspensor tip. A little later stage in development is shown in figure 15 in which two embryos in B are more advanced than those in A from the same group. A similar stage is further shown in figure 16 in which four embryos developed at the same prosuspensor tip from left to right are at 5-, 2-, 5- and 7-celled stages. Even a more divergent example is shown in figure 18 in which one embryo remains at 2-celled stage while other three embryos are in more advanced stages. Up to this moment the prosuspensor cells still remain together though the embryos orientate in various ways.

Figure 17 shows the total view of an embryo complex with two embryo systems. Here one system develops normally and four multicellular embryos are formed at the prosuspensor tip with the supernumerary prosuspensor cell left behind, while the prosuspensor cells in the other system separate from the upper part and no embryo initials or embryos are found at their tips. The multifold windings and coilings of the prosuspensor cells are remarkable. These cells remain unicellular. Similar example is further shown in figure 24 in an advanced stage. The actual length of the prosuspensor cells is not easy to determine. In one case, however, they are measured as long as 3.8 cm. when stretched out in dissection.

Figure 19 shows four multicellular embryos at the prosuspensor tip which tend to separate. The embryo at the left is 4-celled, while the oldest one at the right above is 16-celled and two younger embryos below are 2- and 7-celled. The separation of the embryos is due to the unequal growth of the prosuspensor cells. This separation marks the beginning of cleavage polyembryony. This is further shown in figure 23 and also in figure 24.

The next stage is the formation of the embryonal tubes around the basal region of the multicellular embryo. Figure 20 shows an embryo at the tip of the prosuspensor cell. The vacuolated and large cells in the basal region become embryonal tubes. The embryo at the right in figure 18 also represents the formation of the embryonal tubes. Figure 23 shows four embryos in a later stage in which the lower part of prosuspensor cells separate from each other with embryos at different stages at their tips. Here two embryos of a few cells each are seen above and the terminal one remains at the multicellular stage, while the fourth embryo forms very long embryonal tubes which grow backward from the basal region of the embryo. Figure 24 shows the massive and numerous embryonal tubes in the terminal embryo which is destined to be a successful one in the mature seed. The embryonal tubes are also developing in two younger embryos while the fourth one remains undivided. Figure 25 shows four embryos at the prosuspensor tip at greater magnification. Here three embryos are forming massive embryonal tubes while the fourth one remains at 4-celled stage. A similar condition is also illustrated in figure 28 where three of the four embryos are forming the embryonal tubes successively while the terminal one remains at the stage of a dozen of cells. The embryo at the right may be the successful one as shown by its position and mass. The embryo beyond the stage shown in figure 28 is not followed.

The apical cell is present in the early growth of the embryo. But it is not shown in these surface drawings when the embryo becomes multicellular. It is found as late as the stages represented by figs. 26 and 27 from the sectioned preparations. The existence of apical cell is illustrated in *Taxodium* by Coker (9). In case of *Glyptostrobus* sometimes it is not easy to identify the apical cell in the earliest embryo since the first wall formed in the division of the embryo initial is usually transverse instead of inclined as described above.

DISCUSSION

POLYEMBRYONY.—It was shown that each embryo system regularly has four embryo initials which form separate embryos at the prosuspensor tip, and there are no rosette cells and no embryos developing in the position of a rosette. The total number of

the embryos per fertilized egg is naturally four. The number of embryo systems in an embryo complex varies from one to six. If this number is multiplied by four the product is the number of individual embryos that may be developed in an embryo complex. But actually the number of embryos developed is far below the theoretical number. This is due to the fact that many embryo systems may deviate from the normal development during the early stages. Their prosuspensor cells may separate all the way through and usually lose the contact with the embryo initials at their tips. Other abnormalities in development further reduce the number of embryos developed. Cleavage polyembryony is, therefore, less extensive in *Glyptostrobus* than in *Cryptomeria* and *Cunninghamia* as reported by Buchholz (2,6) and in *Taxodium* as reported by Coker (9) and Kaeiser (12). It seems that the competition among the embryo systems in a given embryo complex plays an important rôle in the first place during embryonic selection prior to the formation of the individual embryos.

COMPARISON IN EMBRYOGENY OF GLYPTOSTROBUS AND TAXODIUM.—The embryogeny of *Glyptostrobus* resembles, in general, that of *Taxodium* (9,12) more nearly than that of any genus in the conifers. In *Taxodium,* the eight free nuclei in the proembryo are arranged into two tiers before the wall formation begins. Usual distribution is 6 in the upper tier and 2 in the lower tier. Transverse divisions in the upper tier give rise to open tier and prosuspensor tier, while vertical divisions in the lower tier result in the formation of four embryo initials. So that the proembryo of *Taxodium* has 6 open cells, 6 prosuspensor cells and 4 primary embryo cells. Two proembryos of *Glyptostrobus* have been found to have the same number of 16 cells arranged in three tiers. Since only a few ovules were available during the proembryo stages no conclusion can be drawn for the moment. However, judging from the number of prosuspensor cells in the later stages 4 to 4 arrangement is probably of more common occurrence. It appears that the competition among the embryo systems in *Taxodium* is not so keen as in *Glyptostrobus.* With the earlier embryonic selection before the embryo units at the tip of the prosuspensor become active, *Glyptostrobus* shows a higher degree of specialization and is more advanced in the evolutionary series. Kaeiser (12) found the single-celled primary suspensor in rare instances in *Taxodium,* while it is completely omitted in *Glyptostrobus.* In *Taxodium* Coker (9) reported that the wall in the first division of the embryo initials is almost always inclined, while in *Glyptostrobus* it is usually transverse, occasionally inclined and rarely vertical.

Aside from these differences the similarities in embryogeny between *Glyptostrobus* and *Taxodium* are very striking. Both form long prosuspensor; both have four embryo initials which form independent embryos at different stages; both have no rosette cells and no embryos developing in the position of a rosette. The apical cell growth in each embryonic unit and the development of embryonal tubes are also similar. In general both have no single-celled primary suspensor.

Buchholz (6) states that there is general agreement in early embryogeny of *Cunninghamia, Cryptomeria* and *Taxodium.* They resemble each other not only in their manner of development of proembryo but also in their polyembryony, in forming long prosuspensor which may become embryonic, and in the usual absence of a primary suspensor. It is not necessary to repeat here in details.

With the knowledge obtained from the investigation of early embryogeny of *Glyptostrobus*, it is believed that *Glyptostrobus* belongs to the group which also includes *Cunninghamia*, *Cryptomeria* and *Taxodium*. Through the selection of embryo systems during the early stages and the reduced number of embryos developed per complex *Glyptostrobus* stands at the specialized end of this series.

SUMMARY

Fertilization took place in the first week of June, 1947.

Three simultaneous divisions of the fertilized egg result in the formation of eight free nuclear proembryo and the walls are formed among them. The proembryo is arranged in three definite tiers, an open tier which is exposed above to the cytoplasm of the egg, a tier of 4-6 cells forming a prosuspensor, and 4 embryo initials at the tip of the prosuspensor.

The number of embryo systems per complex varies from 1 to 6, with the mean, $2.61 + 0.082$ and standard deviation, 1.16. 36.8% of the total embryo systems gives rise to normal embryos; 59% forms isolated prosuspensor cells which usually lose the contact with the embryo initials, and 4.2% develops embryonic prosuspensor and other abnormalities.

The wall formed in the first division of the embryo initials is usually transverse, occasionally inclined and rarely vertical. The embryo initials at the tip of the prosuspensor form independent embryos and different stages are found in the embryos developed from the same embryo system.

There are no rosette cells and embryos developing in the position of a rosette.

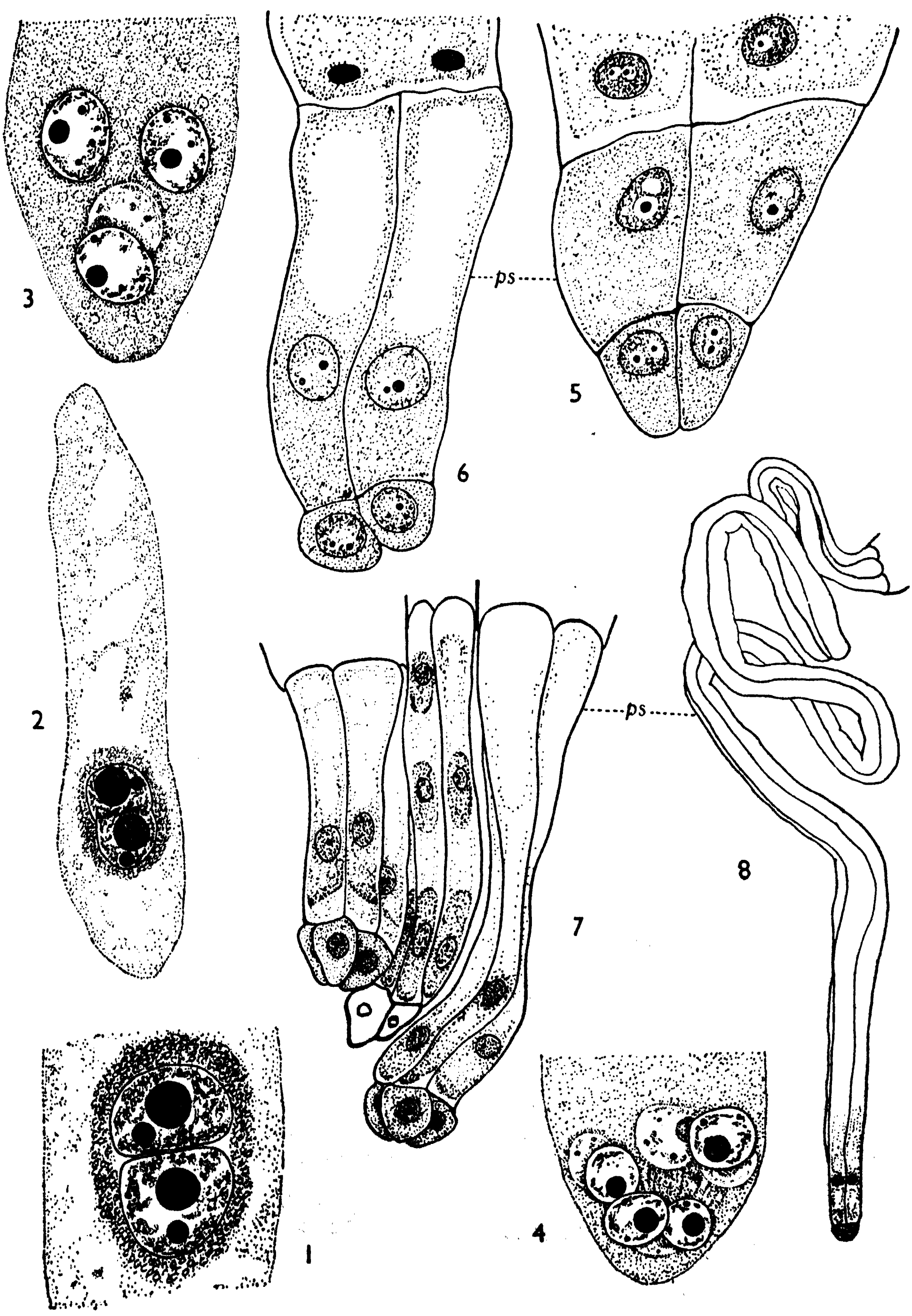
The apical cell growth occurs in the early stages of the embryo.

The single-celled primary suspensor is completely omitted, while the embryonal tubes are well developed in the basal region of the embryo.

The embryogeny of *Glyptostrobus* resembles, in general, that of *Taxodium* not only in its general features of proembryo formation and its cleavage polyembryony, but also in the fact that some of the prosuspensor cells may become embryonic. Both genera have definitely 4 embryo initials which form independent embryos; both have no rosette cells and embryos developing in the region of a rosette; both are usually without primary suspensors. However, with the selection of embryo systems and the reduced number of embryos developed per complex it is believed that *Glyptostrobus* stands at the specialized end of the series which includes *Cunninghamia*, *Cryptomeria* and *Taxodium*.

EXPLANATION OF FIGURES

Fig. 1-28. Embryogeny of *Glyptostrobus pensilis*. Description in text.—Fig. 1, x 530, June 10.—Fig. 2, x 300, June 10.—Fig. 3, 4, 5, 6, x 530, June 10.—Fig. 7, x 265, June 10.—Fig. 8, x 58, June 28.—Fig. 9, x 50, June 25.—Fig. 10, x 50, June 28.—Fig. 11, 12, 13, x 218, June 28.—Fig. 14, 15, 16, x 218, July 4.—Fig. 17, x 50, June 28.—Fig. 18, x 218, July 4.—Fig. 19, x 200, July 7.—Fig. 20, x 200, July 10.—Fig. 21, x 97, July 1.—Fig. 22, x 97, July 4.—Fig. 23, x 46, July 4.—Fig. 24, x 20, July 7.—Fig. 25, x 218, July 7.—Fig. 26, x 218, June 28.—Fig. 27, x 218, July 7.—Fig. 28, x 105, July 10. *ps*, prosuspensor; *et*, embryonal tubes.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7
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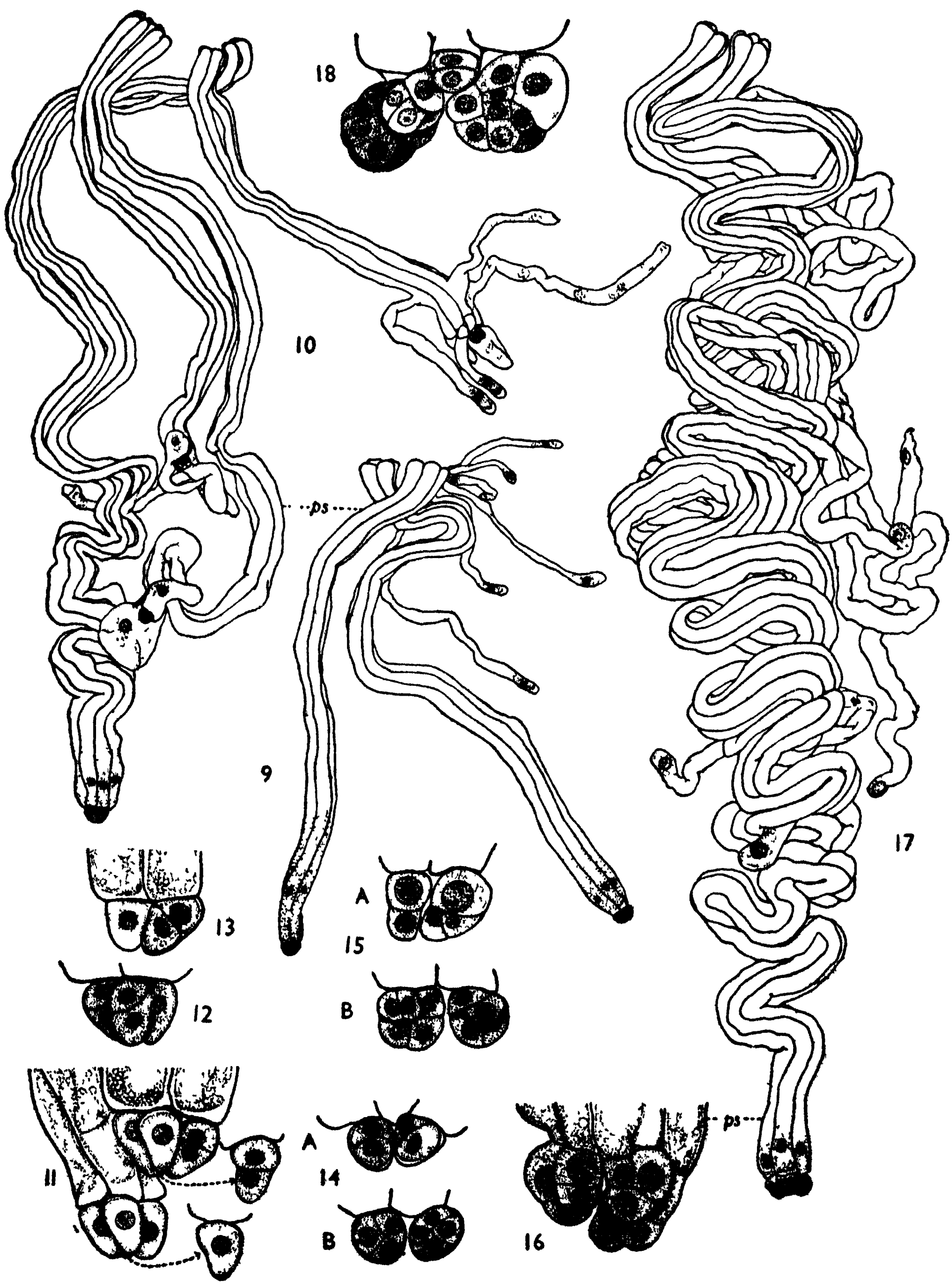
4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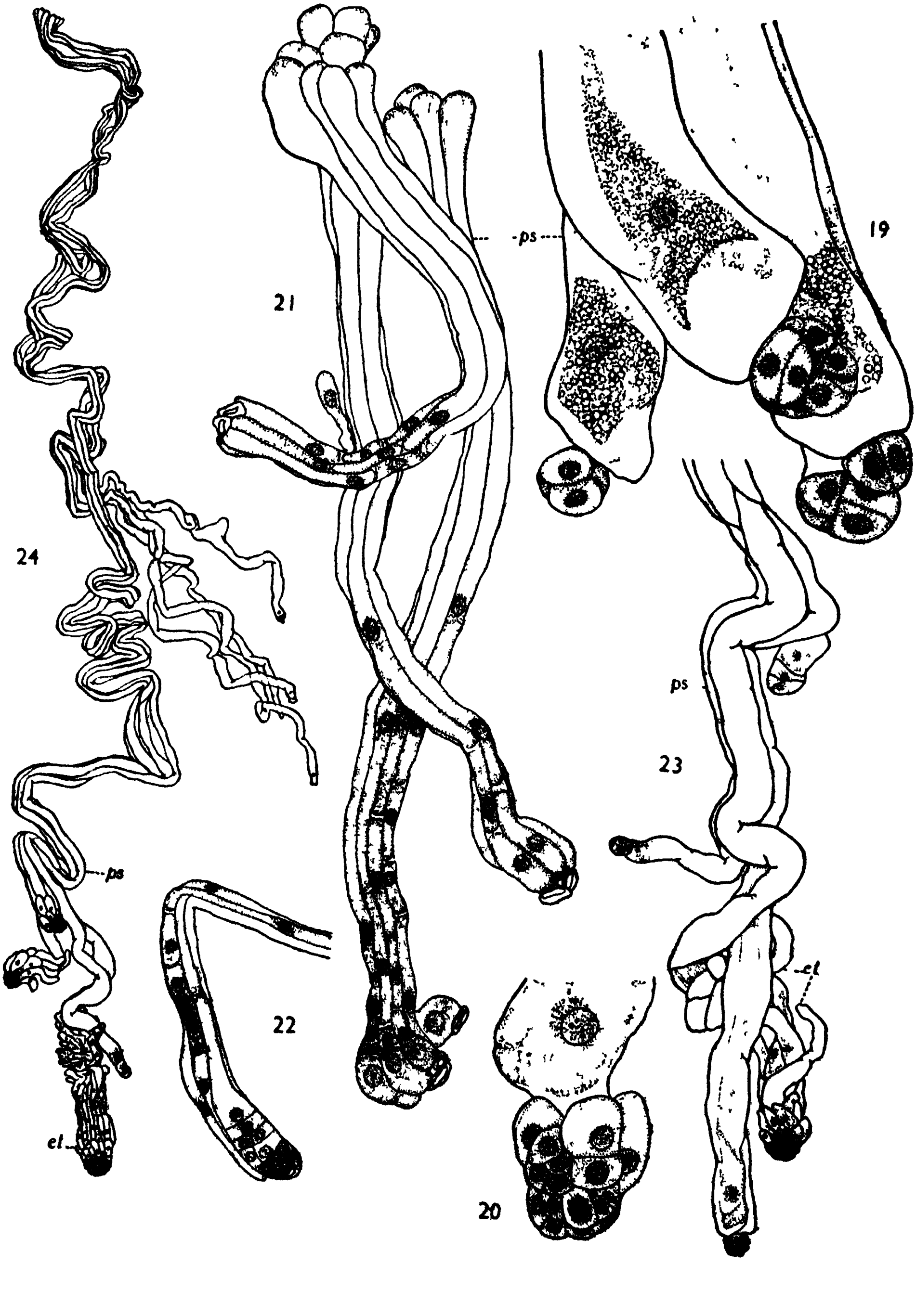
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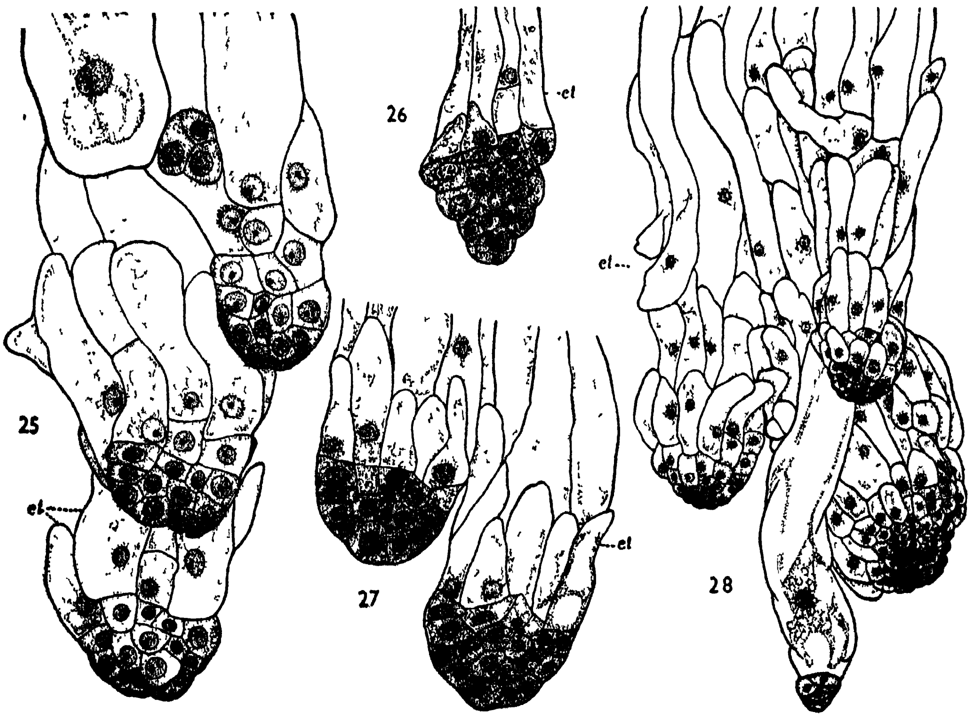

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OBSERVATIONS ON THE EMBRYOGENY OF JUNIPERUS CHINENSIS

S. H. TANG

The early embryogeny of *Juniperus* has been described by Cook (5) as "a new type of embryogeny in the conifers" based upon the observations of the dissected material of *Juniperus communis.* From the similarity of the embryogeny of *Juniperus* to that of *Ephedra* and *Gnetum* she concludes that a relationship between the Coniferales and the Gnetales through the Cupressaceae is established. However, the embryogeny of the Chinese species has not yet been reported. The present paper is to describe the embryogeny of *Juniperus chinensis* with some new facts.

MATERIAL AND METHODS

The material for this investigation was collected from a cultivated female tree on the ground of Academia Sinica, Shanghai, from February to November in 1947. All the ovules collected were well pollinated, since two male trees were found about five meters away.

The fresh material was killed and fixed both in F. A. A. and modified Navashin's fluid. For the study of fertilization and proembryo formation the usual paraffin method was followed. For the stages following the elongation of prosuspensors the Buchholz (4) method was employed. The staining method with Haidenhain's iron-alum haematoxylin as described by Wang (17) was used.

OBSERVATIONS

FERTILIZATION AND PROEMBRYO FORMATION.—Pollination of *Juniperus chinensis* occured toward the end of March and fertilization took place in the third week oı June, 1947, Shanghai. The interval between pollination and fertilization is about 11 weeks. Prior to fertilization, the pollen tubes squeeze through the nucellus and the neck cells. The fusion of the male nucleus and the egg takes place in the upper part of the archegonium. They are nearly of the same size (fig. 1). Then the fertilized egg moves down to the base of the archegonium. The division of the zygote results in the formation of two free nuclei (fig. 2). Simultaneous division of these two nuclei gives rise to four free nuclei (fiig. 3). Figure 4 represents the eight free nuclear stage after the third division. Soon after the free nuclei have become arranged in more or less two tiers. The upper tier usually consists of four or five cells while the lower tier, four or three cells. Their arrangement are shown in figures 5 and 6. Figure 5 shows 3 to 5 arrangement, while figure 6 shows 4 to 4 arrangement. The wall is formed at this stage. The complete proembryo consists of twelve cells arranged more or less in three tiers (fig. 7). The cells of the upper tier remain open above to the cytoplasm of the egg and contribute nothing in the further development of the embryo; the middle tier is prosuspensor which pushes the cells of the lower tier out of the archegonium into the female gametophyte by elongation.

The development of proembryo of *Juniperus chinensis* is mainly the same as that of *Juniperus communis* as reported by Noren (12) and Nichols (11).

Development of the Embryo.—Scon after the prosuspensor cells have elongated and pushed the suspensor-embryo initials at their ends out of the archegonium down to the tissue of the female gametophyte the suspensor-embryo initials soon begin to elongate (fig. 9). In figure 9, the archegonium and jacket layer have collapsed and the endosperm cells near the initials have been digested away and displaced. Moreover, it seems that the suspensor-embryo initials grow toward different directions. This fact may be considered as a vestige of the proembryonic cleavage polyembryony. As in *Biota* and *Libocedrus* the prosuspensor may cease to elongate rather early; while the tier below them continuously elongate and may give rise to variously lobed tubes same as those described by Cook (5) in *J. communis.* These lobed and unlobed tubes derived from the suspensor-embryo initials are always interwined into a compact knot. Figure 10 shows two embryo systems from two fertilized eggs in a complex with their upper part much interwined and collapsed but still without cutting off the terminal embryo cells.

From figures 10, 11, 12, 13 it is evident that the prosuspensor cells may become embryonic and develop in various abnormal ways. Figure 10 shows a three-celled tube that extends out from the upper end of a prosuspensor cell. Figure 11 shows two prosuspensor cells which have become inflated at the upper end and form two deformed multicellular embryos. Figure 12 shows a prosuspensor cell which has become separated from the others. Figure 13 shows a prosuspensor cell which has become inflated at the lower end and cut off an abnormal embryonic cell. From these observations the fact that the prosuspensor is a potential embryo initial as suggested by Buchholz (3) in *Chamaecyparis* is substantiated. Occasionally some segments of the suspensor tubes (figs. 14, 17) may become embryonic. The development of these abnormal structures derived from embryonic prosuspensor cells and suspensor tubes may suppress the further development of the embryo proper, or, the reverse may be true.

After the upper portion of the suspensor tubes has collapsed, the embryo initial is cut off. Figures 15, 16, and 17 show the formation of such initials by a transverse division of the last suspensor tubes. Figure 15 shows one out of three suspensor tubes cutting off the embryo initial. In figure 16 one out of three branches of a lobed suspensor tube cuts off the embryo initial. Figure 17 shows a two-celled embryo.

The embryo becomes multicellular by the growth of an apical cell. Figure 18 shows an apical cell found in the young embryo. And this apical cell lasts for some time as shown in figure 19. However, it finally loses its identity, as shown in figure 21 in which an apical cell can be no longer detected in the terminal embryo, while it is clearly shown in the upper two aborted embryos.

The next stage in the development is the formation of embryonal tubes. Figures 19, 21, 22 show that the embryonal tubes are developed from the upper parts of the embryos and that they grow backwards toward the archegonium complex. The successive growth of these embryonal tubes forms a massive secondary suspensor. Figure 20 shows an abnormal case in which the embryonal tubes are not well developed.

Vegetative budding of the multicellular embryo has been found in one case. This is shown in figure 22. It seems that this budding phenomenon is similar to that of *Cupressus arizonica* (6), *Biota orientalis* (2), *Libocedrus decurrens* (2), *Widdringtonia cupressoides* (10), and that of *Gnetum* (7).

DISCUSSION

The interval between pollination and fertilization in *Juniperus chinensis* is about 11 weeks, whereas in *Juniperus communis* it is about 12½ months. However, this is longer than that in *Juniperus virginiana* (13) in which the interval between pollination and fertilization is only 7 weeks.

In the proembryo as soon as the third free nuclear division is completed and the nuclei are orientated into two tiers, the separating membranes among them are gradually laid down. Wall formation takes place in this stage, same as in *Juniperus communis* as reported by Noren (12) and Nichols (11). In *Juniperus chinensis* the cells of the lowest tier in the proembryo begin to elongate without first cutting off embryonic cells at their tips. This agrees with *Juniperus communis* as reported by Cook (5). And it seems safe to say that Strasburger's (14) description of the skein of tubes in the ovules of *Juniperus communis* is incorrect in so far as he assumes that the terminal cells is lost during dissection.

Since the suspensor-embryo initials grow at first toward different directions, a vestige of proembryonic cleavage may be recognized. The proembryonic cleavage polyembryony, however, occurs in *Ephedra* and *Gnetum*. Thus the similarity between Gnetales and *Juniperus* in this respect is obvious.

Since the prosuspensor cells become multicellular and cut off end-cells and since the suspensor tubes may become embryonic, it appears that each of the walled cells in the proembryo of *Juniperus chinensis,* just like that in *Ephedra* (8, 9) and *Gnetum* (7), is a potential embryo initial.

Moreover, it is of some interest to find a budding phenomenon of late cleavage in young multicellular embryo in *Juniperus chinensis,* as this also occurs in *Gnetum* (7) and *Biota* (2), *Libocedrus* (2), *Widdringtonia* (10) of Cupressaceae.

The similarities in embryogeny of *Juniperus chinensis* and *Gnetum* or *Ephedra* are in (1) the organization of the proembryo; (2) the presence of proembryonic cleavage; (3) the elongation and branching of the embryo initials; (4) the embryonic potentialities of each walled cell in the proembryo; and (5) the vegetative budding phenomenon in young multicellular embryo.

The question of the affinity between Gnetales and Coniferales has already been discussed by a number of workers such as Thompson (16, 17), Buchholz (1, 2), and Cook (5). The knowledge obtained from the study of the embryogeny of *Juniperus chinensis* also supports this hypothesis.

SUMMARY

Pollination of *Juniperus chinensis* occurs at the end of March, while fertilization takes place about the third week of June. The interval between pollination and fertilization is about 11 weeks.

The wall formation of the proembryo usually takes place as the eight free nuclei are reorientated. The complete proembryo consists of the open tier, the prosuspensor tier, and the suspensor-embryo initial tier. There are normally four cells in each tier. The fact that the lowest cells of the proembryo elongate without cutting off embryo initials but repeatedly cutting off many suspensor tubes, and that the upper portion of the

suspensor tubes become collapsed, shows that *Juniperus chinensis* is similar to *J. communis* as described by Cook (5).

The embryo initial is transversely cut off from the last suspensor tube. The individual embryos of *Juniperus chinensis* were found to develop by apical cell growth though it is no longer detectable in the later stages.

Both prosuspensor cells and suspensor tubes may become embryonic by internal cell proliferation, or by some other abnormal ways.

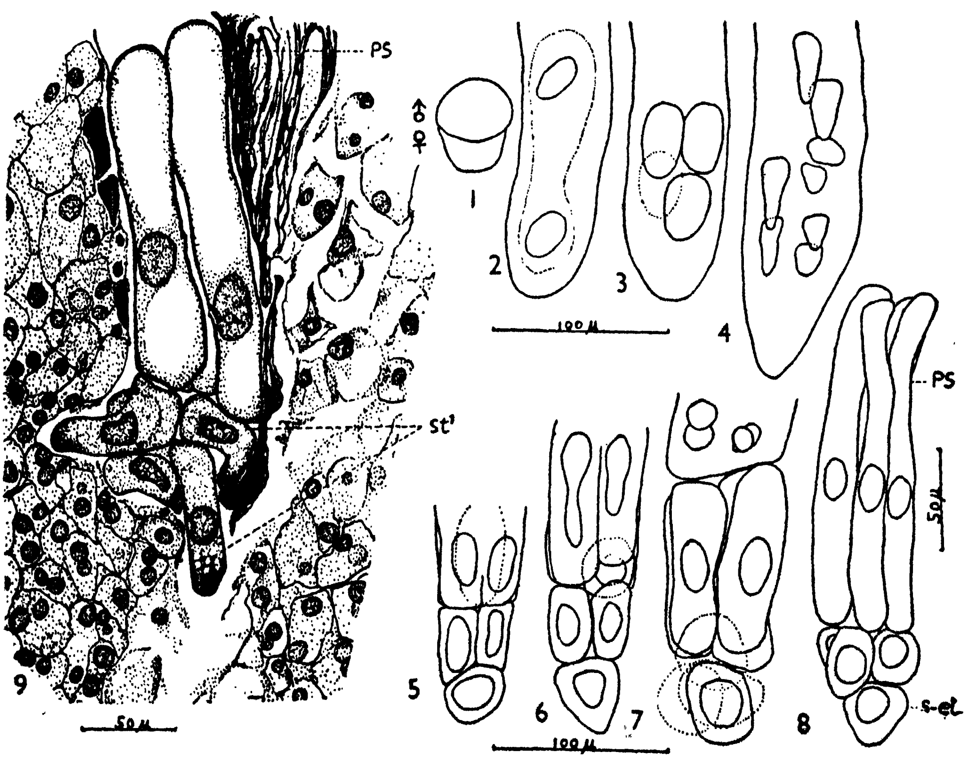
Budding phenomenon has been found in a young multicellular embryo.

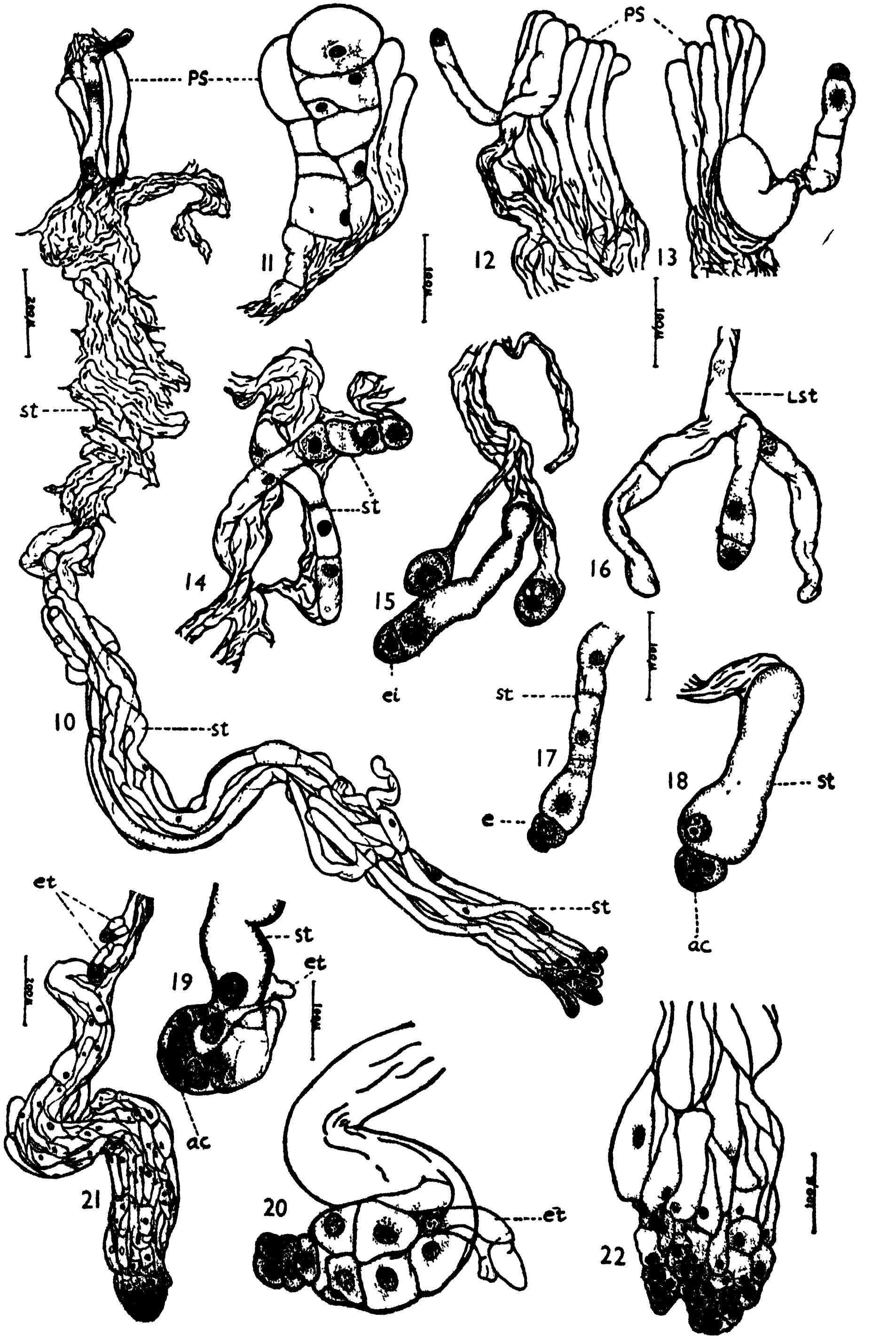
In general feature, the early embryogeny of *Juniperus chinensis* is similar to that of *Juniperus communis.*

The author wishes to express his thanks to Dr. F. H. Wang under whose direction this work has been done.

EXPLANATION OF FIGURES

Fig. 1-22. Embryogeny of *Juniperus chinensis*. Description in text.—Fig. 1, outline drawing of fusion.—Fig. 2-8, outline drawings of proembryo formation.—Fig. 9, elongating first suspensor tubes.—Fig. 10, total view of two embryo systems.—Fig. 11, 12, 13, prosuspensors.—Fig. 14, 15, suspensor tubes. —Fig. 16, lobed suspensor tube.—Fig. 17, 18, 19, 20, young embryos.—Fig. 21, multicellular embryo.—Fig. 22, later cleavage. *s-ei*, suspensor-embryo initial; st^1, first suspensor tube; *ps*, prosuspensor; *st*, suspensor tube; *ei*, embryo initial; *e*, embryo proper; *1st*, lobed suspensor tube; *ac*, apical cell; *et*, embryonal tube.

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NOTES ON TAMARICACEAE OF CHINA

CHIEN P'EI

Tamaricaceae is a small plant family composed of five genera with about one hundred species widely distributed in both hemispheres. There are three genera, *Tamarix*, *Myricaria* and *Hololachne*, reported indigenous in western parts of China. Three or four species of *Tamarix* have been collected here and there, but the collectors usually state the plants being cultivated. Owing to the collector's statement, I suspect that most of *Tamarix* species have been introduced from Europe to Chinese gardens. Due to their adaptation to Chinese soil and climate they are more or less changed in gross morphology. The new names given to certain Chinese cultivated forms may be considered right. For the convenience of field botanists, a short description of each species and tentative keys to genera and species are given.

FAMILY CHARACTERS—Undershrubs or small trees; leaves alternate, minute or scale-like, exstipulate, sometimes fleshy or impress-punctate; flowers solitary, spiked, racemose, or panicled-racemose, bisexual; sepals and petals 5, rarely 4, imbricate, usually free or connate at the base; stamens 4-5-10-indefinite, inserted on the disk, free or connate below; anthers versatile; disk hypogynous or subperigynous, 5-10-glandulose;

ovary free, 1-celled or imperfectly septated; styles usually 3, rarely 5, free or connate; stigmas 3, rarely 5, sometimes sessile; ovules 2-indefinite on each basal placenta, anatropous; fruit a tri-valved capsule; seeds erect, usually plumed on apex or winged, with floury or subfleshy albumen or exalbuminous; embryo straight; cotyledons flat.

5 genera and about 100 species widely distributed in both hemispheres; 3 genera with about 10 species distributed in China.

KEY TO GENERA

1. Petals without ligule on the inside ....2.
1. Petals with ligule on the inside .... *Hololachne*
2. Stamens free inserted on the disk; styles 3, dilated at the apex .... *Tamarix*
2. Stamens connate at the base or to half of their length; styles connate with sessile stigma ...*Myricaria*

TAMARIX Linnaeus

Bushes or small trees; leaves minute, scale-like, amplexicaul or sheathing; flowers in lateral or terminal spikes or dense racemes, white or pink; calyx and corolla 5-merous, rarely 4; stamens 4-10 (usually 5 in Chinese species), anthers apiculate; disk more or less lobed from varying confluence of glands; ovary cylindrical, narrowed upwards; styles 3, rarely 4, short, dilated at the tip into the stigmas; ovules many, seeds exalbuminous, with plumose apex, plume sessile; embryo ovoid.

About 25 species widely distributed in both hemispheres; 3 species commonly cultivated in China.

KEY TO SPECIES

1. Disk-lobes distinctly bi-lobed; bract obovate at the lower portion, apiculated ....*T. pentandra*
1. Disk-lobes not bilobed; bract ovate-lanceolate or linear, apiculated or obtuse at the apex ....2.
2. Leaves scale-like, about 1.5 mm. in length, ovate-lanceolate, apiculated; stamens inserted between the disk lobes .... *T. chinensis*
2. Leaves linear-oblong, about 2 mm. in length, acute at the apex; stamens inserted on the disk lobes ....*T. juniperina*

TAMARIX PENTANDRA (Desv.) Pall., Flor. Ross. 1 (8): 72, tab. 79, fig. a-d. 1788.

Tamarix Pallasii Desv., Ann. Sci. Nat. ser. 1. 4: 349. 1825.

Small trees; leaves greenish, small, linear-lanceolate, acute at the apex, 2-3 mm. long on vigorous branchlets; flowers in densely panicled racemes; pedicels about 0.5 mm. long; bracts 4 times longer than pedicels, long-apiculate; calyx lobes less than 1 mm. long; petals obovate-oblong, about 1.5 mm. long; disk lobes deeply bi-lobed; stamens conspicuously exerted.

Shantung: Lao-shan, Hua-ying-sze, *C. Y. Chiao 2853,* July 20, 1930, "Shrub 6 feet high, along rocky slopes".

Hopei: Peiping, Yü-ch'üan-shan, *Y. Yabe,* June 8, 1906.

Kiangsu: Haichow, *W. Y. Yang 3253,* Oct. 7, 1928, "Shrub 7 feet high, flowers pink, common-name: Kuan-ying-liu". Shanghai, *H. Migo,* Sept. 13, 1931 and Oct. 3, 1933. Nanking, *P. C. Chen 277,* May 25, 1935; *C. C. Kung 123,* June 1934.

Distrib: Eastern Europe to Central Asia and Sungaria.

This commonly cultivated species is often named as *Tamarix chinensis* Lour. from which it differs particularly by its bilobed disk lobes and conspicuously exerted stamens.

Tamarix chinensis Lour. Fl. Cochinch. 182. 1790.

Tamarix gallica β *chinensis* Ehrenb., Linnaea 2: 267. 1827.

Tamarix indica Bunge, Mem. Sav. Etr. Acad. Sci. St. Petersb. 2: 102. (Enum. Pl. Chin. Bor. 28), 1833, non Willd.

A glabrous small tree or bush about 2 meters tall; leaves alternate, ovate-lanceolate, about 1.5 mm. in length, apiculate; flowers in terminal racemes; bract ovate-lanceolate, apiculated, about 1 mm. long; pedicels less than 1 mm. long; calyx connate at the base, 5 toothed, teeth ovate in shape, less than 1 mm. long; petals obovate-oblong, obtuse to truncate; stamens inserted between the disk lobes, usually exerted; disk lobes sometimes slightly emarginate; styles 3, dilated at the apex.

Sinkiang: Ngê-min, Chin-ch'ang, *C. Lin 161*, "Red willow".

Kansu and Tsinghai border: Without precise locality, *Y. C. Wu.*

Anhwei: Without precise locality, *Y. Tsiang*, 1926.

Szechuan: Without precise locality, *W. P. Fang 5405*, Oct. 4, 1930.

Kweichow: Chengfeng, *Y. Tsiang 4427*, Oct. 25, 1930.

Yunnan: Menghua, near Wuliang-shan, *Y. Tsiang 12118*, Sept. 26, 1933, "Tree of 7 meters high".

Tamarix chinensis Lour. has its type locality in the Kwangtung province. It is said to be widely cultivated in many places in China. It is very much similar to *Tamarix gallica* Linn. from which it differs by its alternate leaves and distinct disk lobes.

Tamarix juniperina Bunge in Mem. Sav. Etr. Acad. Sci. St. Petersb. 2: 102. (Enum. Pl. Chin. Bor. 28). 1833.

Tamarix chinensis Sieb. et Zucc. Fl. Jap. 1: 132, t. 71. 1840, non Lour. Diels, Not. Bot. Gard. Edinb. 7: 91. 1912.

Small trees; leaves linear, 2-3 mm. long, acute at the tip; flowers in terminal panicled racemes; pedicels about 1.5 mm. long; bract linear-oblong, 2 mm. long, obtuse at the apex; flowers small, pinkish; sepals united at the base, lobes ovate; petals oblong; stamens 5 with equal length of filaments, slightly exerted; disk 5-lobed, stamens adnate to each of the lobes; styles 3, dilated into stigmas.

Shantung: Tsingtao, along sea shore, *C. Y. Chiao 2400*, June 7, 1930, "Flowers pinkish".

Hopei: Tang-ku, *S. Nohara 31*, May 19, 1943. Lu-tai, *S. Nohara 72*, May 22, 1943.

Shansi: S. Shansi, alt. 850 m., tomb side, *T. Tang 769*, May 16, 1929, "Bush, 15-20 feet high, C. B. H. 1 foot, bark dark yellowish-grey, fissured in striate flakes, flowers pink".

Distrib: Also in Mongolia and Yunnan.

This species is markedly different from the preceding species by its larger leaves, linear bracts which are rounded at the apex, and by its stamens inserted on the disk lobes.

Myricaria Desvaux

Fastigiate shrubs; leaves small, sessile, often crowded; inflorescence racemose, terminal or axillary; flowers rose pink; calyx 5, united at the base; petals 5; stamens usually 10, rarely 8, with filaments equal in length or alternately long and short, dilated below, connate at base or to the middle of filaments; ovary superior, tapering to the apex with 3 sessile stigmas; ovules many; seeds exalbuminous with a stalked plume; embryo ovoid.

About 10 species widely distributed in the Old World; 5 species are recorded in China.

KEY TO SPECIES

1. Flower and leaf buds indistinct; inflorescence usually terminal on this year's branchlets..........2
1. Flower and leaf buds distinct; inflorescence usually on last year's branchlets..........*M. dahurica*
2. Stamens usually 8, rarely 10, united at the base; bracts as long as the pedicels......*M. alopecuroides*
2. Stamens usually 10, united to the middle of filaments; filaments unequal; bracts twice as long as the pedicels .... *M. bracteata*

MYRICARIA ALOPECUROIDES Schrenk apud Fischer et Meyer, Enum. Pl. Nov. 65. 1841.

Myricaria germanica Desv. var. *alopecuroides* Maxim. Fl. Tangut 96. 1889.

Bush up to 3 m. tall; leaves small, linear, 2-5 mm. long; inflorescence in terminal racemes or panicled racemes; bracts linear-ovate, as long as the pedicels; flowers pinkish; sepals narrowly ovate, 2 mm. long, white margined; petals oblong, twice as long as the sepals; stamens 8, united near the base; filaments equal, dilated below, entire; ovary tapering to the apex, with sessile stigmas.

Shansi: N. Shansi, alt. 5500 feet, open ravine, *T. Tang 1194,* July 24, 1929, "Shrub, 2 feet high, flowers pink".

Szechuan: Without precise locality, *Y. Y. Ho 6813,* 1935.

Yunnan: Menghua city, alt. 1700 m. in open woods, *Y. Tsiang 11722,* Sept. 5, 1933. "Leaves green, flowers purplish".

Distrib.: Also in Mongolia and Kansu.

This species is characterized by its terminal inflorescence with bracts as long as the pedicels and by its stamens united at the base with filaments of equal length.

MYRICARIA BRACTEATA Royle, Ill. Bot. Himal. 214. t. 44. 1839.

Myricaria Hoffmeisteri Klotz. Bot. Ergeb. Reise Prinz Waldem. t. 25. 1862.

Myricaria germanica Dyer, Hook. f. Fl. Brit. Ind. 1: 250. 1875, non Desvaux. Hemsl., Jour. Linn. Soc. Bot. 23: 347. 1888, excluso synon. "Myricaria alopecuroides".

Bushes up to 3 m. tall, with slender and striate stems, when young glaucous-green; leaves linear-lanceolate, 2-4 mm. long; inflorescences in panicled racemes, lateral racemes up to 10 cm. long; pedicels about 2 mm. long; bracts lanceolate, 3 times or more longer than the pedicels, with broadly membranaceous margins tinged pink; sepals united at the base, lanceolate, 3 mm. long, broadly membranaceous-margined; petals oblanceolate, 4 mm. long, about 1 mm. broad; stamens 10 united to half of the filaments, filaments unequal, entire.

Szechuan: Without precise locality, *W. P. Fang 9566.*

Distrib.: From Europe to temperate and alpine Himalaya and Siberia; also recorded in the provinces of Hupeh and Kansu.

This species differs from the other species of this genus by its broadly membranaceous margin of the bracts, and its stamens entire and connate for half of their length.

MYRICARIA DAHURICA (Willd.) Ehrenb., Linnaea 2: 278. 1827.

Tamarix dahurica Willd., Abh. Akad. Wiss. Berlin 1812/13. 85. 1816.

Myricaria germanica Desv. var. *squamosa* (Desv.) Maxim. Fl. Tangut, 96. 1889.

Bushes up to 2 m. tall, with purple, smooth and striate bark; inflorescences lateral on last year's branchlets, 5-10 cm. long; in simple racemes; pedicels about 2 mm. long; bracts rounded, 4 mm. long and broad, with broadly membranaceous margin, irregularly

serrulate; flowers pink; calyx connate, 5-lobed, lobes linear and spatulate, with membranaceous margin, 3 mm. long, 1 or less than 1 mm. broad; petals 5, obovate-oblong, obtuse or with few teeth at the tip, 5 mm. long, 2 mm. or more broad; stamens usually 10, connate to half their length, unequal, 5 longer and 5 shorter, dilated below, longer filaments twice as broader as the shorter ones, dilated portion of the filaments occasionally toothed.

Shansi: S. Shansi, alt. 1220-1650 m. along ravines, *T. Tang 774,* May 18, 1929, "Flowers pink".

Sinkiang: Chao-su, T'eksu-ho, *C. Lin 372.*

Kansu: Kilien-shan, *C. K. Chow 14, 155,* July-Aug. 1945. Hinglung-shan, *C. K. Chow,* 1945.

Kansu and Tsinghai border: *Y. C. Wu 303.*

Szechuan: Mt. Omei, *K. Y. Yen.*

Distrib.: Also in Tibet.

This species is characterized by its lateral inflorescence, rounded bracts with broadly membranaceous margin, and broadly dilated longer filaments.

HOLOLACHNE Ehrenberg

A low prostrate bush with deeply penetrating and strong tap-root; leaves minute, alternate; flowers solitary, in axils of the leaf, with 3 subtending bracts; sepals 5, connate to half their length; petals 5, ligulate below; stamens 6-8, rarely 10, slightly exerted; anthers dorsifixed; ovary tricarplary, loculicidally septated; ovules 4 in each cell, 2 on each basal placenta, with 3 styles and minute stigmas; capsule 3-valved; seeds erect, plumose at base.

A monotypic genus in Central Asia and China.

HOLOLACHNE SONGARICA (Pall.) Ehrenbg., Linnaea 2: 273. 1827.

Tamarix songarica Pall., Nov. Act. Acad. Petrop. 10: 374. 1797.

Bushes about 15 cm. tall; leaves minute, sessile, sparsely arranged, nearly cylindric, glaucescent, about 2 mm. long, less than 1 mm. broad; flowers light pinkish, small, fully opened ones about 4 mm. across; calyx connate to half their length, with 5 ovate teeth, tooth about 1 mm. long, with membranaceous margin; petals small, about 3 mm. long, oblong in shape, with two ligules at the lower portion; ligules oblanceolate, oblique at the apex, with few teeth; stamens free, dilated below; ovary ovoid, with 1.5—3 mm. long styles; stigmas small; capsule dehiscent into three valves.

Inner Mongolia: 23 miles N. E. of Tumur Hada, sandy and stony steppes, *Y. L. Keng 3227* (*572*), July 31, 1935, "Flowers whitish pink".

Kansu: Hosi, *C. K. Chow 161,* July-Aug. 1945.

This species is common in arid regions of northwestern China. It is also recorded in Siberia Altai. It differs from the species of other genera by its ligulate petals and free stamens.

A NEW SPECIES OF EUTREMA

Tai-Yien Cheo

Most species of *Eutrema* of the family Cruciferae are naturally distributed in mountainous regions of Oriental Asia. Four species have been found in Western China, and this new one has been collected by H. Migo from Chekiang and wrongly identified by him as *E. yunnanense* Franch.

Eutrema reflexa sp. nov.

E. yunnanense Migo, Journ. Shan. Sci. Ins. Sect. III, V, 4, p. 147. 1939. (non Franch.) syn. nov.

Herba perennis, circiter ½-metralis alta, erecta, flaccida, glabra vel leviter pilosa; rhizoma perpendicularis, radix fibrosa; folia radiata, late ovata, crenata, obtusa et auriculata ad basin, 2½-8 cm. longa et 3½-11 cm. lata; palmatinervis, vena terminus adnata instructa ampliata; petiola vaginata ad basin, 10-20 cm. longa; folis caulinis minutis, ovatis vel triangulatis, undulatis, apicalis obtusis, basi cordatis, petiola 1½-3 cm. longa; flores minuti, in simplice termino racemi, ebracteati; pedunculi 12-15 cm. longi, pilus acutus, minutus dissipatus, deorsum obliquus; sepala 4, erecta, obovata et truncata ad basin, 2 mm. longa et dimidio lata, cum pilis tenuis et maxime minutis; petala 4, alba, puberula, oblonga, apice rotundata, basi in unguiculum brevissimum contracta, limbi patentes, 3-4 mm. lati; stamina 6, filamenta tota, basi leviter dilatata, 2 mm. longa; anthera oblonga, dorsifixa; pistilum ellipsoideum vel ampullaceum; stigma capitata, sessilia; fructus immaturus, brevibus, linearibus, teretus, inaequaliter latus vel leviter flexus; semen parvum, uniseriatum, 2-4 per cubiculum, ovatum, strium, non alatum, cum funiculis permenentibus; pedicelli fructiferi, tenuis, filiformes, circiter 15 mm. longi, conspicue reflexi.

Perennial herb, about ½ m. high, erect, flabby, glabrous or slightly pilose; rhizome perpendicular, with fiberous roots; radial leaves broadly ovate, crenate, obtuse, and auriculate at the base, 2½-8 cm. long and 3½-11 cm. broad; palmately-veined, veins ended with an enlarged structure along the margin, petiole sheath-like at the base, 10-20 cm. long; cauline leaves smaller, ovate or somewhat triangular, undulate, obtuse at apex, cordate at base, petriole about 1½-3 cm. long; flowers small, in simple terminal raceme, ebracteate; peduncle 12-15 cm. long, scattered with soft, hoary and pointed hairs, obliquely downward; sepals 4, erect, obovate and truncate at base, 2 mm. long and half as wide, with fine and very minute hairs; petals 4, white, puberulent, oblong, apex rounded, shortly clawed, spreading limbs 3-4 mm. broad; stamens 6, filament entire, slightly dilated toward the base, about 2 mm. long; anthers oblong, dorsifixed; pistil ellipsoid or flask-shaped, stigma capitate, sessile or nearly so; immatured fruit short, linear or terete, unequally sided or slightly curved; seeds young, uniseriate, 2-4 in each cell, ovate, grooved, wingless, with persistent funicles; fruiting pedicel slender, filiform, about 15 mm. long, conspicuously reflected.

Chekiang: Hsi-tien-mu-shan, *H. Migo,* Apr. 23, 1936, Flowering and young Fruiting Type.

This plant was wrongly identified by H. Migo as *E. yunnanense* Franch. which is characterized by panicled racemes and bracteate lower flowers. In the present species, the raceme is ebracteate and simple, with reflected fruiting pedicels. A closely related

Japanese species, *E. Wasabi* (Siebold) Maxim., differs from the present one in having bracteate raceme and short stipitate silique. The pedicels of both *E. yunnanense* and *E. Wasabi* are not reflexed after bloom.

Fig. 1. *Eutrema reflexa* Cheo, sp. nov. A. Habit; B. Flower; C. Sepal; D. Petal; E. Stamens, showing dorsal & side views; F. Pistil with pedicel; G. Immatured fruit; H. Young seed.

NOTES ON ACTINIDIA OF SZECHUAN AND SIKANG

CHIEN P'EI and Y. W. LAW

Actinidia is composed of about twenty-eight species widely distributed in eastern Asia, from Japan and Korea southward to China, Malay Peninsula, India and Java. Most of the species are endemic in south-western provinces of China. This paper is a preliminary one concerning only a part of the Chinese species. A tentative key is given for those who are interested in this group of plants.

GENERIC CHARACTERS.—Deciduous or evergreen climbing shrubs; branchlets usually brown or chestnut-brown, with white to brown, solid or lamellate pith; buds usually submerged, glabrous or tomentose; leaves very variable, oblong, elliptic, elliptic-oblong, ovate, ovate-oblong to orbicular, glabrous to tomentose, usually setosely serrulate, with appressed or spreading setae and parallel veinlets; stipule usually none; petiole usually slender and long, glabrous to tomentose; inflorescence usually adaxil to the leaf, hermaphrodite flowers solitary or cymose, male flowers in simple cyme or cymose, usually with rudimentary ovary; flowers 4-5-merous, from white to red in color; sepals 4-5, connate at base, enlarged and reflexed in fruit; petals 4-5, imbricate or valvate; stamens numerous up to 50 or more; anthers versatile, opening by longitudinal slit; ovary many-celled, glabrous or tomentose, bottle-shaped, ovoid to long cylindric, with many styles up to 15 or more; fruit a berry, with or without spots; seed numerous, small, albuminous; embryo straight.

KEY TO SPECIES

1. Pith lamellate .... 2.
1. Pith solid .... 10.
2. Flowers usually 5-merous .... 3.
2. Flowers usually 4-merous .... *A. tetramera.*
3. Fruit with spots .... 4.
3. Fruit without spots .... 7.
4. Fruit long-cylindric .... *A. curvidens.*
4. Fruit oblong .... 5.
5. Pith brown; leaves elliptic, rarely elliptic-oblong; lateral veins 10 pairs .... *A. callosa.*
5. Pith white; leaves elliptic-oblong, ovate to ovate-oblong; lateral veins usually 8 pairs .... 6.
6. Leaves usually elliptic-oblong, rounded at base .... *A. venosa.*
6. Leaves broadly ovate to ovate-oblong, usually truncate at base .... *A. pilosula.*
7. Glaucescens of leaves white, persistent .... *A. hypoglauca.*
7. Glaucescens of leaves bluish, disappearing in age .... 8.
8. Fruit not rostrate, greenish or yellowish .... *A. kolomikta.*
8. Fruit rostrate, purple or dark .... 9.
9. Lamellate pith white; leaves with appressed setae at the margin; fruit purple .... *A. purpurea.*
9. Lamellate pith brown; leaves with spreading setae at the margin; fruit dark .... *A. melanandra.*
10. Leaves glabrous or slightly setose on veins; fruit not tomentose .... 11.
10. Leaves tomentose beneath; fruit tomentose .... *A. chinensis.*
11. Leaves usually sparsely setose, chartaceous; fruit without spots; pith white .... *A. polygama.*
11. Leaves glabrous, coriaceous; fruit with spots; pith yellow .... *A. coriacea.*

ACTINIDIA CURVIDENS Dunn, Kew Bull. 1. 1906.

Actinidia callosa Lindl. var. *Henryi* Maxim., Act. Hort. Petrop. 9: 36. 1890.

Woody climbers up to 7 m.; branches gray with conspicuous lenticels; pith lamellate, buff-yellow, becoming brown on old branches; leaves glabrous, broadly elliptic to elliptic-ovate, acuminate at the apex, rounded to broadly cuneate at the base, setosely serrulate, chartaceous, 6-12 cm. long, 3-6 cm. broad, with seven pairs of lateral veins, glabrous above, tufted hairs in axils of lateral veins beneath; petiole 2-5 cm. long; flowers axillary or adaxillary, usually solitary or clustered in threes, 1.5 cm. across; pedicels 1.5—10 cm. long; sepals oblong to obovate, obtuse, persistent, reflexed in fruit, 5 mm. long; petals obovate, 8 mm. long; ovary densely hairy; fruit glabrous, spotted, elongate-cylindric, obtuse, 1.5—3 cm. long, 5—10 mm. diam.

Szechuan: Nanchuan-hsien, Chinfu-shan, alt. 6000—7000 ft., *W. P. Fang 1105,* May 27, 1928; *W. P. Fang 1350,* June 1, 1928; *K. L. Chü 1128,* "Flowers white". Mt. Omei, *H. L. Hsü 662*; *Y. Y. Ho 5678,* Aug. 1, 1935; *Y. Y. Ho 5727,* Aug. 3, 1935. Hungya-hsien, Wawu-shan, Shih-tzu-ping, *C. W. Yao 2178,* July 7, 1939, "Fruit with reddish spots"; *C. W. Yao 2631,* Aug. 1, 1938.

Distrib.: Also in Hupeh and Kweichow.

This species is characterized by its long and cylindric fruit with conspicuous spots.

ACTINIDIA VENOSA (Dunn) Rehd., Sargent's Pl. Wilson. 2: 383. 1915.

Actinidia callosa Lindl. f. *D.* Dunn, Jour. Linn. Soc. Bot. 39: 406. 1911.

Woody climbers up to 9 m.; branchlets chestnut-brown, with whitish lenticels; pith white, lamellate, more purplish and tomentose when young; leaves membranaceous, oblong to elliptic-oblong, acute to short acuminate at apex, usually rounded at base, dentately or setosely serrulate, sparsely pilose above, tomentulose beneath, 6-11 cm. long, 3.5—5 cm. broad; petioles pubescent, 2—3.5 cm. long; bud-scales brown-tomentose; peduncle white-tomentose; young fruit and persistent sepals densely brown-tomentose; fruit subglobose, densely tomentose, spotted.

Szechuan: Kuan-hsien, alt. 3000—3600 ft. in woods, *W. P. Fang 2220,* July 14, 1928.

Distrib.: Also in Hunan.

The species is distinguished from the related species by its chestnut-brown branchlets with whitish lenticels and white-lamellate pith, by its elliptic-oblong and membranous leaves with conspicuous parallel veinlets, and by its tomentose flower and fruit.

ACTINIDIA PILOSULA (Finet. et Gagnet) Stapf, Sched, apud Hand-Mazz. Sym. Sin. 7: 390. 1931.

Actinidia callosa Lindley var. *pilosula* Finet. et Gagnet, in Bull. Bot. France 52: mém. 4, 19. 1905; Contrib. Fl. Asia Arient. 2: 19. 1907: Dunn, Jour. Linn. Soc. Bot. 39: 406. 1911.

Climbing shrubs; branchlets glabrous, gray, with conspicuous lenticels and white lamellate pith, leaves broadly ovate to ovate-oblong, shortly acuminate at apex, usually truncate at base, setosely serrulate, subglabrous above, pubescent on veins beneath when young, with about 8 pairs of lateral veins, chartaceous, 7—13 cm. long, 5—9 cm. broad; petiole 2—4 cm. long; flowers 3—5 cymose; pedicel short and slender, yellowish-pubescent; sepals elliptic to obovate-oblong, yellowish-pubescent; fruit oblong, 2 cm. long, spotted.

Szechuan: Hung-ya, Wa-shan, *C. W. Yao 2466,* July 23, 1938.

Sikang: Huang-ni-pao, *Y. C. Yang 3460,* Aug. 8, 1939.

Distrib.: Also in Yunnan.

This species is easily recognised by its thin and white lamellate pith and its glabrous and truncate leaves.

ACTINIDIA CALLOSA Lindl. Nat. Syst. Bot. ed. 2. 439. 1836.

A woody climber up to 7 m.; branchlets chestnut-brown, glabrous, with conspicuous lenticels and brown-lamellate pith; leaves chartaceous, elliptic to elliptic-oblong, setosely serrulate, acuminate at apex, cuneate to broadly cuneate at base, sparsely puberulent above, with brown hairs on veins beneath, 6-10 cm. long, 2.5—4 cm. broad, with about 10 pairs of veins; petiole slender, 1.5—2 cm. long, glabrous; flowers single or in simple cymes; peduncle about 1 cm. long, glabrous; pedicels tomentose, about 8 mm. long; sepals reflexed in fruit, oblong, obtuse, tomentose with brown hairs outside, fruit broadly oblong, spotted, brown-tomentose when young, about 2 cm. long.

Sikang: Mupin, Ma-huang-kou, alt. 2400 m., *C. P'ei 8197,* Sept. 4, 1938, "Fruit brown".

Distrib.: From Central China and Luchou Islands to India, Burma and Java.

This species is easily distinguished from the related species by its elliptic leaves which are nearly glabrous with about 10 pairs of lateral veins, by its brown lamellate pith and by its brown tomentose calyx.

ACTINIDIA HYPOGLAUCA sp. nov. (Fig. 1)

Frutex scandens, ramulis puberulis, purpurinis; folia chartacea, longe petiolata, oblonga vel ovato-oblonga, acuminata, setoseo-serrulata, subtus glauca, glabra, scabra axillis nervorum secondarinorum lateralium excepta, supra viridia, glabra; petiolo circiter 4.5 cm. longo; flores circiter 2 cm. diam.; masculi in cymis, 3-floris, petala obovata; sepala oblonga; stamina circiter 50; flores hermaphroditi ignoti.

Woody climbers; branchlets glabrous or sparsely villose, purplish in color; pith lamellated, brown in color; lenticels not conspicuous; leaves oblong, or broadly oblong, rarely ovate-oblong, acuminate at the apex, unequally rounded or subtruncate at the base, lustrous green above, glaucous with scrabrous tufts in axils of the lateral veins beneath, chartaceous, 9-11 cm. long, 5—7 cm. broad, lateral veins usually 6—7 pairs; petiole glabrous, 3—5 cm. long; inflorescence a simple cyme; male flowers about 2 cm. in diameter; peduncle 1.5—2 cm. long; pedicel 10—14 mm. long; sepals connate at the base, oblong or obovate-oblong, on dry specimen black in the central portion, about 4 mm. long, glabrous; petals obovate, about 8 mm. long, 4 mm. broad, glabrous, black in central portion; stamens numerous, 40—50 in number, nearly equal; filament attached at the base of the connective; rudimentary ovary present, conical in shape; hermaphrodite flower not seen.

Szechuan: Opien, *T. H. Chao 304* (TYPE).

This species is characterized by its glaucous leaves and inflorescence in simple cymes. It is very much like *A. rubricaulis* Dunn, from which it differs by the characteristics mentioned above. It is also related to *A. melanandra* Fr. from which it differs by its persistent glaucescens.

Fig. 1. *Actinidia hypoglauca* P'ei, sp. nov.: A. Branchlet with male flowers; B. Flower, top view; C. Flower, back view; D. Petal; E. Stamens; F. Calyx with rudimentary ovary.

ACTINIDIA KOLOMIKTA Maxim., Mem. Acad. Sci. St. Petersb. 9: 63. 1859; Bull. Acad. Sci. St. Petersb. 31: 19. 1886.

Prunus ? Kolomikta Maxim. et Ruprecht, Bull. Acad. Sci. St. Petersb. 15: 219. 1857.

Kalomikta mandshurica Regel, Bull. Acad. Sci. St. Pétersb. 15: 219. 1857.

Trachostigma kolomikta Ruprecht, Bull. Acad. Sci. St. Petersb. 15; 262. 1857.

Actinidia platyphylla A. Gray apud Miquel, Ann. Mus. Lugd.-Bat. 3: 15. 1867.

Woody climbers up to 4—7 m.; branches glabrous, purplish red, with conspicuous lenticels and lamellate pith; leaves ovate-oblong, sparsely pubescent and scabrous on veins above, sparsely hairy beneath, acuminate at apex, rounded to cordate at base, setosely serrulate, membranaceous, 10—12 cm. long, 4-10 cm. broad, sometimes with white or pink blotches at the apex extending often to the middle or beyond; flowers usually 1 or in simple cyme, axillary or on adaxils of leaves; peduncle densely puberulent, 1—2 cm. long; sepals broadly ovate, densely puberulent, 5 mm. long; petals obovate; stamens glabrous; ovary glabrous; fruit oblong-ovoid, 2—2.5 cm. long, unspotted.

Szechuan: Mt. Omei, *T. H. Tu 235,* 1935; *C. W. Yao 4712,* Aug. 26, 1939; *C. W. Yao 5187,* Sept. 16, 1939. O-pien, Hsa-ping, *C. W. Yao 2816,* Aug. 21, 1938; *C. W. Yao 4318,* July 29, 1939; *C. W. Yao 4325,* July 20, 1939; *T. H. Chao 339* and *661.* Mt. Omei, *S. S. Chien 6092,* July 12, 1937. Kuan-hsien, *W. P. Fang 2239,* July 15, 1928.

Sikang: T'ien-ts'üan-hsien, alt. 2200—2600 m. among bushes, *K. L. Chü 2751,* June 11, 1936. Mupin, alt. 2450 m., among bushes, *K. L. Chü 3051,* June 3, 1936; *K. L. Chü 3437,* Aug. 6, 1936; *K. L. Chü 3532,* Aug. 11, 1936.

Distrib.: Widely distributed in N. E. Asia, Japan, Central and Western China.

This species is distinguished from its related species by the pink and white blotches on its leaves, by its greenish or yellowish fruit, and by its brown lamellate pith.

ACTINIDIA PURPUREA Rehd., Sargent's Pl. Wilson. 2: 378. 1915.

Woody climbers up to 7 m.; branchlets gray, glabrous, with white-lamellated pith; lenticels white, inconspicuous, when young densely pubescent; leaves oblong or broadly ovate, abruptly acuminate at apex, rounded to truncate at the base, sometimes unequal, appressedly serrate, dull green and opaque above, tufted hairs in axils of veins on both surfaces, chartaceous, 7—15 cm. long, 4.5—9 cm. broad; petiole 3—5 cm. long, pubescent; buds submerged, glabrous, reddish; female flowers 1—5; fruit oblong, glabrous, unspotted.

Szechuan: Shui-tung-shan, *C. W. Yao 4181,* July 16, 1939.

Sikang: T'ien-ts'üan-hsien, Hung-shan-ping, *C. L. Wu 12083,* Aug. 12, 1940.

Distrib.: Also in Yunnan.

This species is closely related to *Actinidia arguta* Miq. from which it differs by its white-lamellate pith and its appressed serration.

ACTINIDIA MELANANDRA Franch., Jour. De. Bot. 8: 278. 1894.

Actinidia rufa var. 4. *parvifolia* Dunn., Jour. Linn. Soc. 39: 403. 1911.

Woody high climbers: branchlets brown, with conspicuous lenticels and lamellate pith; leaves elliptic-ovate to oblong, acuminate at apex, rounded to broadly cuneate at base, setosely serrulate, glabrous except tufts of hairs in the axils of veins beneath, 6—10 cm. long, 4—5 cm. broad, petiole 2—3 cm. long, inflorescence glabrous, about as long as the petiole, in simple cyme, adaxil to the leaves; ovary bottle-shaped, glabrous; fruit oblong-elliptic, 2.5—3 cm. long, shortly rostrate, unspotted, glabrous.

Szechuan: Kuan-hsien, alt. 3500—4000 ft., in thickets, *W. P. Fang 2364,* July 14, 1928; Without precise locality, *W. P. Fang 7957,* Aug. 5, 1930.

Distrib.: Also in Japan.

This species is easily recognised by its partly glabrous and glaucous leaves with tufted hairs on axils of veins and by its short-rostrate fruits.

ACTINIDIA TETRAMERA Maxim., Act. Hort. Petrop. 11: 35. 1890.

Clematoclethra Giraldii Diels, Bot. Jahrb. 29: 472. 1900.

Woody climbers; branchlets glabrous, gray to light brown, with conspicuous lenticels; pith lamellated; leaves ovate-oblong to elliptic, 5—10 cm. long, 2—3 cm. broad, acuminate, rounded to cuneate or slightly cordate at the base, axil of veins with tufted hairs, sparsely pilose on midribs of both surfaces, setosely serrulate; petiole slender, sparsely pilose, 2—4.5 cm. long; bud-scales few, glabrous; male flowers usually in simple axillary cyme; hermaphrodite flowers usually single, auxillary; petals white tetramerous; sepals ovate, villose, reflexed in fruit; fruit ovoid to oblong, 1—1.5 cm. long, glabrous.

Szechuan: Mt. Omei, in thickets, *W. P. Fang 3063,* Aug. 16, 1928; *W. P. Fang 6559,* July 17, 1930; *T H. Tu 220,* 1935; *Y. Y. Ho 5770,* Aug. 6, 1935; *Y. Y. Ho 5938,* Aug. 10, 1935. Hungya-hsien, Wawu-shan, Shih-tsu-ping, *C. W. Yao 2134,* July 5, 1938; between Yüan-yang-ch'ih and Shuang-tung-ch'i, in thickets, *C. W. Yao 2473,* July 23, 1938, "Fruit greenish, tinged with red color"; Hsia-t'ien-ch'ih, in thickets, *C. W. Yao 3602,* June 18, 1939; Chun-t'ien-ch'ih, *C. W. Yao 3637,* June 18, 1939; vicinity of Luo-han-kao, *C W. Yao 3750,* June 22, 1939, "Veins shaded with red color, flowers red"; Tai-tsu-tien, *C. W. Yao 3825,* June 25, 1939, "Flowers red".

Distrib.: Also in Kansu and Shensi.

This species is closely related to *Actinidia kolomikta* Maxim. from which it differs by its narrower leaves with stiff hairs on midribs and tufted hairs in axils of the vein and by its sparsely pilose petiole. The specimens cited above are slightly different from those from the type locality, in having hairs which are brown in color and softer. The other characters are the same as those of the northern plants.

ACTINIDIA POLYGAMA Maxim. Mém., Sav. Etr. Acad. Sci. St. Pétersbourg, 9: 64. 1859.

Trochostigma polygama Sieb. et Zucc., Abh. Munch. 3: 727. t. 2, fig. 2. 1843.

Trochostigma volubilis Sieb. et Zucc., l.c. 1843.

Actinidia volubilis Miq., Ann. Mus. Lugd. Bot. 3: 15, 1867.

Woody climber up to 7 m.; branchlets glabrous with white solid pith; leaves broadly ovate, ovate-oblong to elliptic oblong, acuminate at apex, broadly cuneate, rounded or subcordate at base, setosely serrulate to denticulately serrulate, strigose above, setose on the veins beneath, membranous, 7—13 cm. long, 5—7 cm. broad, lateral veins about 8 pairs; petiole slender, setose when young, 1.5—2.5 cm. long; flowers usually solitary or in simple cyme, pedicel slender, scabrous, 1 cm. long; sepals elliptic-oblong, thin, puberulent on both sides, 5 mm. long; petals oblong-obovate, 1 cm. long; anthers yellow; ovary glabrous, bottle-shaped; fruit yellow, oblong-ovoid, unspotted, rostrate, 3 cm. long.

Szechuan: Hung-ya, Wa-wu-shan, on way from Tung-ch'i to Sin-szu, fruit reddish *C. W. Yao 2570* July 27, 1938; vicinity of Shih-tzu-ping, 'flowers white' *C. W. Yao 3620* June 18, 1939; vicinity of Shih-t'ung-kou, *C. W. Yao 3671,* vicinity of Ping-ling-t'su, *C. W. Yao 4054.*

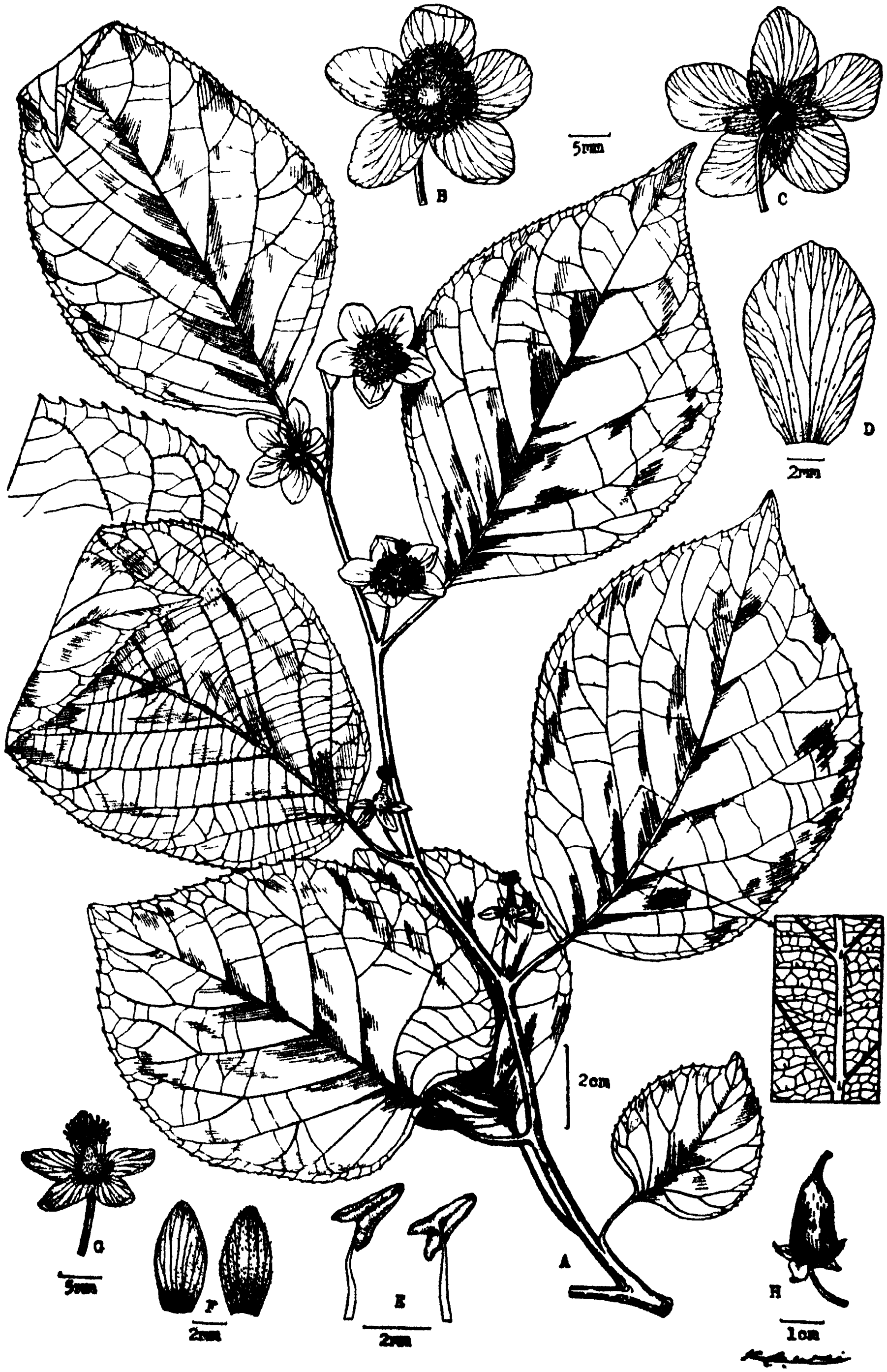

Fig 2. *Actinidia polygama* Maxim.: A. Branchlet with hermaphrodite flowers; B. Flower, top. view; C. Flower, back view; D. Petal; E. Stamens; F. Sepals; G. Calyx with ovary; H. Fruit.

Sikang; Pao-hsing-hsien, Chao-yang-tsun, Hsia-chang-peng-shan, alt. 2200 m. 'Leaves green above, light green beneath; fruit light yellow.' *K. L. Chu 3760,* Aug. 30, 1936; vicinity of Teng-chih-kou, alt. 2000 m. 'leaves light green, fruit light yellow'; *K. L. Chu 3874,* Sept. 17, 1936; Yung-ching-ping, road side, *C. W. Yao 2141,* July 5, 1938; Pao-hsing-hsien, Yeh-mao-ping to He-tao-ping, alt. 1500 m. 'Shaded slope, fruit orange, *C. Pei 8116,* Aug. 30, 1938.

Distrib.: Also in Korea and Japan.

This species is characterized by its white solid pith and yellow, rostrate, unspotted fruits.

ACTINIDIA CORIACEA (Finet et Gagnep.) Dunn, Jour. Linn. Soc. Bot. 39: 405. 1911.

Actinidia callosa Lindl var. *coriacea* Finet et Gagnep., Bull. Soc. Bot. France, 52: Mem. 6, 20. 1905; Contrib. Fl. As. Or. 2: 20. 1907.

Evergreen woody climbers; branchlets reddish, with conspicuous lenticels; pith solid; leaves elliptic-oblong to ovate-lanceolate, remotely serrulate and mucronate, abruptly acuminate or acute at apex, broadly cuneate to rounded at base, glabrous on both surfaces, coriaceous, 6—12 cm. long, 2—4.5 cm. broad; petiole glabrous, 1—4 cm. long; flowers small, single to few or racemose, borne laterally or in axil of leaves; sepals pubescent within and without, ciliate on margin; petals glabrous; ovary densely hairy; fruit spotted, ovoid to cylindrical.

Szechuan: Huayung-shan, Ta-an to Mu-lung-tung, in thickets, *Y. C. Yang 4183,* March 17, 1941, "Flowers in buds reddish". Chungking, Peipeh, Chinyün-shan, on slopes, *K. L. Chü 6637,* Nov. 26, 1938; *Y. C. Yang 3218,* May 18, 1938; *C. P'ei 7498,* Oct. 25, 1940. Nanchuan-hsien, Chinfu-shan, *K. L. Chü 1044*; *Y. Y. Ho 4083,* May 26, 1935, "Leaves deep green above, greenish beneath"; *Y. Y. Ho 4305,* June 2, 1935, "Flowers pinkish"; *Y. Y. Ho 5282,* June 30, 1935, "Fruit brownish"; *Y. Y. Ho 5794,* Aug. 6, 1935, "Fruit brownish green with gray dots". Mt. Omei, alt. 1300 m., *W. P. Fang 12756,* July 30, 1938; *C. W. Yao 3377,* Oct. 1938; *K. Y. Yen 3299.* O-pien, *T. H. Chao 835.* Hungya-hsien, Wawu-shan, Shih-tsu-ping, *C. Y. Yao 3595,* June, 17, 1939, "Fowers red"; *C. W. Yao 3670,* June 19, 1939. Without precise locality, *W. P. Fang 271,* May 20, 1930; *W. P. Fang 769* and *2113,* 1928; *W. P. Fang 4633,* June 28, 1930; *W. P. Fang 4818,* Aug. 6, 1930; *C. L. Wu 12203.*

Sikang: Lushan-hsien, Ch'inglung-ch'ang, Jên-chia-shan, alt. 1150 m., *K. L. Chü 4049,* Oct. 19, 1936.

Distrib.: Also in Kweichow and Yunnan.

This species is characterized by its cordiaceous, remotely mucronat-serrulate leaves and red flowers.

ACTINIDIA CHINENSIS Planch. Hooker's Lond. Jour. Bot. 6: 303. 1847.

Woody climber up to 4 m., branchlets red, villous, with lamellate pith; winter buds chestnut-brown; leaves orbicular, ovate to obovate, retuse to bilobed or obtuse to apiculate at apex, usually broadly cuneate or subcordate at base, setosely serrulate, dark-green, with hairs on veins above, tomentose with stellate hairs and reddish villose on veins beneath, chartaceous, 8—12 cm. long, 5—12 cm. broad; petioles up to 6 cm. long, densely hairy; flowers single or in simple cyme, in axil of leaves; flowers 3—4 cm. across, white, quickly changing to yellow, fragrant; sepals ovate, densely tomentose of

chestnut-brown color; petals obovate-cuneiform; fruit ovoid to subglobose, 3—5 cm. long, with brown hairs, edible.

Szechuan: Nanchuan-hsien, Chinfu-shan, alt. 6000—7000 ft., in thickets, *W. P. Fang 1084,* May 27, 1928; *H. P. Chang 89,* June 3, 1935; *Y. Y. Ho 4126,* May 30, 1935; *K. L. Chü 928* and *1038*. O-pien, Sha-ping, *C. W. Yao 4516,* Aug. 8, 1939.

Sikang: Hung-ya, Wawu-shan, Shih-tzu-ping, *C. W. Yao 2082,* July 4, 1938; *C. W. Yao 3575,* June 17, 1939. Mupin, Mei-li-chuan, alt. 240 m., in bushes, *K. L. Chü 2893,* June 20, 1936, "Woody vine, flowers white". Mupin, Yeh-miao-ping, alt. 1500 m., in woods, *K. L. Chü 6274,* Aug. 30, 1938. Without precise locality, *C. L. Wu 12178.*

Distrib.: Very common in the provinces south of the Yangtze River.

This is a beautiful species with large and white flowers changing quickly to buff-yellow. The fruit is large and fragrant, being used locally for preparing jam.

THE ALGAL GENUS LAGERHEIMIA CHODAT

SHANG-HAO LEY

In the course of the writer's work on the planktonic algae of South China, some species of the genus *Lagerheimia* Chodat have been recorded by him (12). During the identification work he carried on, he found that the generic diagnosis of *Lagerheimia* Chodat given by different algologists vary in some characteristics, and, therefore, wishes to make a critical study on this matter. Recently, Dr. S. C. Teng of the Institute kindly told me that *Lagerheimia* is also a fungous genus of Ascomycetes established in 1892 (17). As we know that the algal genus *Lagerheimia* was established in 1895, it is necessary to give a new generic name for this algal genus. Before discussing on these, a brief historical review regarding to the establishment and other relations of the algal genus should be preluded.

In 1889, De Toni (7) divided the genus *Oocystis* Naegeli into two subgenera, one of which characterized by the presence of setae on the wall was named *Lagerheimia,* comprised one species and a variety, i. e., *Oocystis ciliata* Lagerheim and *Oocystis ciliata* Lagerheim var. *amphitricha* Lagerheim. This is the first time the name "Lagerheimia" was used as a subgeneric name for a group of algae.

In 1894, Chodat found a four-spined alga from Geneva water, and named it "Tetraceras" without diagnosis (3). Afterward, in 1895, he (4) raised the subgenus *Lagerheimia* of *Oocystis* to generic rank and considered his "Tetraceras" as its synonym. The generic characteristics of his genus are: "Cellulae solitariae, ellipsoideae vel cylindraceae, apice utroque rotundatae, membrana firma, aculeis 2 — plurivus longis arcuatis subcrassis in utroque fine donatae. Inter aculeos invenitur globulus hyalinus. Chlorophorum parietale chlamydeum, subintegrum, corpusculum amuliferum unum gerens. Multiplicatio zoosporis biciliatis (4—8) saepius sporis vel autosporis (4—8). Invenitur etiam status quiescens palmelloideus." Under his new genus, two species, i. e., *L. genevensis* (= *Tetracera* sp.) and *L. ciliata* (= *Oocystis ciliata* Lagerheim), were listed.

In 1898, Lemmermann (10) added another species to the genus *Lagerheimia*. He named it *L. subsalsa*. In the same year, he established another new genus *Chodatella* (11). It differs from *Lagerheimia* only in having setae not tubercular at their base. In this genus, he listed 7 species, including *Lagerheimia subsalsa*, i. e., *Ch. quadriseta*, *Ch. subsalsa* (= *Lagerheimia subsalsa*), *Ch. longiseta*, *Ch. ciliata* (= *Oocystis ciliata*; *Lagerheimia ciliata*), *Ch. amphitricha* (= *Oocystis ciliata* var. *amphitricha*), *Ch. armata* (= *Golenkinia armata*), *Ch. radians* (= *Oocystis ciliata* var. *radians*).

In 1909, Wille (31) first considered the genera *Tetraceras* Chodat, *Pilidiocystis* Bohlin, *Chodatella* Lemmermann, and *Bohlinia* Lemmermann as synonyms of the genus *Lagerheimia* Chodat, and divided the genus into three sections, i. e., *Eulagerheimia*, *Bohlinia* and *Pilidiocystis*. His opinion was adopted by other algologists (15), but some British algologists still maintain *Chodatella* as a separate genus (25, 28).

In 1916, Playfair (14) grouped the species of *Lagerheimia* with four quadratedly arranged and rigid spines under a new genus *Bernardia*. Under this new genus two species were listed by him, i. e., *B. Chodati* (= *L. Chodati* Bernard) and *B. wratislawiensis* (= *L. wratislawiensis* Schroeder). However, this genus has not been accepted by any other algologists, because the distinction that Playfair used to separate *Bernardia* from *Lagerheimia* is not conspicuous (21). Furthermore, the name "Bernardia" was already given to a genus of Euphorbiaceae by Adanson in 1763 (13, p. 21).

In 1927, Printz (26) divided the genus *Lagerheimia* into three sections, i. e., *Eulagerheimia* (Wille) Printz, *Chodatella* (Lemm.) Printz and *Bohlinia* (Lemm.) Wille, and retained *Pilidiocystis* Bohlin as an independent genus. In 1933, Smith (22) based upon his specimens of *Lagerheimia Echidna* (= *Bohlinia Echidna* Lemm.) from California, North America, retained *Bohlinia* as a good genus, because the individual cells of his specimens are wholly embedded in a common gelatinous matrix to form a flocculent mass. He also suggested that the genus *Chodatella* Lemm., which differs from *Lagerheimia* Chodat only in having the setae not tubercular at the base, should be considered as a synonym of the genus *Lagerheimia*.

To summarize the above, (1) "Lagerheimia" had been used as a subgeneric name of the algal genus *Oocystis* by De Toni in 1889 before Chodat raised it to a generic name in 1895, and validly used as a fungous generic name by Saccardo (17) in 1892. Thus "Lagerheimia" is preoccupied by a fungous genus and can not be used to name any other genus of plants. (2) Among the synonyms of algal genus *Lagerheimia*, *Chodatella* Lemm. was published earlier than any other one. Therefore, the writer proposes to use *Chodatella* Lemm. with emended diagnosis to replace the generic name *Lagerheimia*. Under the genus *Chodatella* the species may be grouped into two subgenera, i. e., *Lagerheimia* (Chodat) and *Euchodatella*. The emended diagnosis of the genus *Chodatella*, a list of its known species, and a working key to the species are giving as follows:

CHODATELLA Lemm., char. emend.

Oocystis Naegeli, ex parte, De Toni, Sylloge Algarum 1: 663. 1889.
Tetraceras Chodat, Archiv sc. phys. naturelles 32: 624. 1894.
Lagerheimia Chodat, Nuova Notarisia 6: 90, figs. 1—12. 1895.
Bernardia Playfair, Proc. Linn. Soc. New South Wales 41: 847, pl. 59. 1916.

Cellulae libere natantes, uninucleatae, solitariae, ovules, ellipsoideae, vel cylindraceae, ad polos rotundatae, membrana firma, in utroque fine setis 2 vel pluribus longis vel brevibus donatae. Chlorophora singula vel plura, laminaeformia vel disciformia parietalia, pyrenoide instructa vel destituta. Propagatio autosporis (2—8).

In 1895, Chodat (4) reported that *Ch. genevensis* (Chodat) reproduces by the two-flagellated zoospores. Since then no any other algologists discovered the zoospores in any other species of this genus. However, Chodat's record seems to be in need of further investigations (cf. 16 p. 122).

Subgenus I. LAGERHEIMIA (Chodat), comb. nov.

Eulagerheimia (Wille) Printz, Die natürlichen Pflanzenfamilien, 2 ed., (Chlorophyceae) 121. 1927.
Tetraceras Chodat, *op. cit.*
Lagerheimia Chodat, *op. cit.*
Bernardia Playfair, *op. cit.*
Setae basi evidenter bulbiformi-inflatae.

Subgenus II. EUCHODATELLA, subgen. nov.

Oocystis Naegeli, *op. cit.*
Chodatella Printz, Die natürlichen Pflanzenfamilien, 2 ed., 3 (Chlorophyceae) 121. 1927.
Setae basi non bulbiformi-inflatae.

KEY TO THE SPECIES

1	Setae swelling at the base	Subgenus *Lagerheimia* 2
1	Setae not swelling at the base	Subgenus *Euchodatella* 7
2	Cells ellipsoid	3
2	Cells subcylindrical	5
2	Cells spherical	***Ch. Chodati***
3	With single seta at each pole	4
3	With 4 setae at each pole	***Ch. octacantha***
4	With 4 setae around the equator	***Ch. Marssonii***
4	With two setae, one at each side of the equator	***Ch. wratislawiensis***
5	Cells less than 6 μ in diameter, with 1 seta at each end	6
5.	Cells 7.5—9 μ in diameter, with 3 to 4 setae at each end	***Ch. splendens***
6	Cells 3 μ in diameter	***Ch. genevensis***
6	Cells 5.5 μ in diameter	***Ch. subglobosa***
7	Setae covered entire cell wall	8
7	Setae only at both ends of the cell	11
8	Setae uniformly distributed on the surface of the cell	9
8	Setae not uniformly distributed on the surface of the cell	10
9	Cells discoid, setae very short	***Ch. brevispina***
9	Cells ellipsoid, setae long	***Ch. armata***
10	Cells 8—9.5 × 12—12.5 μ, with 6 setae	***Ch. breviseta***
10	Cells 5—12 × 10—16 μ, with numerous setae	***Ch. Droescheri***
11	Cells lemon-shaped	12
11	Cell ovoid	13
12	Cell with 4—8 setae at each pole	***Ch. citriformis***
12	Cell usually with 3 setae at each pole	***Ch. Woloszynskae***
13	Setae more than 2 times longer than the cell	14
13.	Setae less than 2 times longer than the cell	15
14.	Cells 8 × 12 μ; 4—10 setae at each pole	***Ch. longiseta***
14.	Cells 4 × 5 μ; 2 setae at each pole	***Ch. quadriseta***
15.	Cells 3.5 × 7 μ; 3—4 setae at each pole	***Ch. subsalsa***
15.	Cells 9—18 × 12—21 μ; 3—8 (usually 6) setae at each pole	***Ch. ciliata***

LIST OF THE SPECIES

Subgenus LAGERHEIMIA (Chodat), comb. nov.

CHODATELLA CHODATI (Bernard), comb. nov.

Lagerheimia Chodati Bernard., Pro'occ. et Desm. d'eau douce 170, pl. 12, figs. 249, 250. 1908.
Bernardia Chodati (Bernard) Playfair, Proc. Linn. Soc. N. S. Wales 41: 847, pl. 59, figs. 3, 4. 1916.
Type locality: Java.

CHODATELLA GENEVENSIS (Chodat), comb. nov.

Tetraceras sp. Chodat, Archiv sc. phyc. naturelles 32: 624. 1894.
Lagerheimia genevensis Chodat, Nuova Notar. 1895: 90, figs. 1—12. 1895.
Type locality: Geneva, Switzerland.

CHODATELLA MARSSONII (Lemm.), comb. nov.

Lagerheimia Marssonii Lemm., Ber. Deutsch. Bot. Ges. 18: 274. 1900.
Type locality: Summt Lake, Germany.

CHODATELLA OCTACANTHA (Lemm.), comb. nov.

Lagerheimia octacantha Lemm., Ber. Deutsch. Bot. Ges. 18: 28. 1900.
Type locality: Wilmersdorfer Lake, Germany.

CHODATELLA SPLENDENS (West), comb. nov.

Lagerheimia splendens West, Jour. Linn. Soc. Bot. 39: 74—75, pl. 6, figs. 4—8. 1909.
Type locality: Victoria, Australia.

CHODATELLA SUBGLOBOSA (Lemm.), comb. nov.

Lagerheimia subglobosa Lemm., Hedwigia 37: 309, pl. 10, fig. 9, 1897.
Type locality: Leipzig, Germany.

CHODATELLA WRATISLAWIENSIS (Schroeder), comb. nov.

Lagerheimia wratislawiensis Schroeder, Ber. Deutsch. Bot. Ges. 15: 373, pl. 17. fig. 7. 1897.
Bernardia wratislawiensis (Schroeder) Playfair, Proc. Linn. Soc. N. S. Wales 41: 847, pl. 59, figs. 3, 4. 1916.
Type locality: Breslau, Germany.

CHODATELLA WRATISLAWIENSIS var. TRISETIGERA (Smith), comb. nov.

Lagerheimia wratislawiensis var. *trisetigera* Smith, Trans. Amer. Microsc. Soc. 45: 181, pl. 12. figs. 15—21. 1926.
Type locality: Okoboji, North America.

Subgenus EUCHODATELLA, subgen. nov.

CHODATELLA ARMATA Lemm., Hedwigia 37: 311. 1898.

Goldenkinia armata Lemm., Forsch. d. biol. Stat. i Plon 6: 193, pl. 5, fig. 7. 1898.
Type locality: Germany.

CHODATELLA BREVISETA W. et G. S. West, Trans. Roy. Acad. Irish 32: B: 69, pl. 1, fig. 16, 17. 1902.

Type locality: Ireland.

CHODATELLA BREVISPINA Fritsch, Jour. Linn. Soc. Bot. 40: 326, pl. 10, figs. 25, 26, pl. 11, phots. 3, 5. 1912.

Type locality: South orkneys, Antarctic.

CHODATELLA CILIATA (Lagerh.) Lemm., Hedwigia 37: 310, 1898.

Oocystis ciliata Legerh., Oefv. af. Kongl. Vetensk. Akad. Foshandl. 1882, pl. 3, figs. 33—37, 1882.
Lagerheimia ciliata (Lagerh.) Chodat, Nuova Notar. 1895: 90. 1895.
Type locality: Sweden.

CHODATELLA CILIATA var. AMPHITRICHA (Lagerh.) Chodat, Matt. Flore Crypt. Suisse 1 (3): 192. 1902.

Oocystis ciliata var. *amphitricha* Lagerh., *in* De Toni, Syll. Alg. 1: 665. 1889.

Lagerheimia amphitricha Wille, Nachtrage zu Chlorophyceae *in* Engler's Naturl. Pflanzenfamilien 1: 58. 1909.

Oocystis ciliata var. *radians* West, Jour. Roy. Microsc. London 1896: 161, pl. 3, fig. 15. 1896.

Type locality: Sweden.

CHODATELLA CILIATA var. MINOR Smith, Bull. Torrey Bot. Club. 43: 477, pl. 25, fig. 16. 1916.

Lagerheimia ciliata var. *minor* Collins, Tufts Coll. Studies 4 (7): 33. 1918.

Type locality: Wisconsin Lake, North America.

CHODATELLA CINGULA (Smith), comb. nov.

Lagerheimia cingula Smith, Trans. Amer. Microsc. Soc. 45: 181, pl. 12, fig. 25. 1921.

Type locality: Okoboji, North America.

CHODATELLA CITRIFORMIS Snow, Bull. U. S. Fish. Comm. 22: 389, pl. 2, fig. 8 (1—3). 1903.

Lagerheimia citriformis Collins, Tufts Coll. Studies 4 (7): 33. 1918.

Type locality: Lake Erie, North America.

CHODATELLA DROESCHERI Lemm., Ber. Deutsch. Bot. Ges. 18: 98, pl. 3, fig. 12. 1900.

Lagerheimia Droescheri Printz, Viden. Skr. 1. Mat.—Naturv. Klass. 1913, no. 6, p. 60. 1914.

Type locality: Elbe, Germany.

CHODATELLA LONGISETA Lemm., Hedwigia 37: 310, pl. 10, figs. 11—18. 1898.

Lagerheimia longiseta Printz, Viden. Skr. 1. Mat.—Naturv. Klass. 1913, no. 6, p. 60. 1914.

Type locality: Germany.

CHODATELLA LONGISETA var. MAJOR (Smith), comb. nov.

Lagerheimia longiseta var. *major* Smith, Wisc. Geol. Nat. Hist. Survey Bull. 56, Sci. ser. no. 12, p. 130, pl. 30, figs. 10—12. 1920.

Type locality: Wisconsin Lake, North America.

CHODATELLA QUADRISETA Lemm., Hedwigia 37: 310, pl. 10, fig. 10. 1898.

Lagerheimia quadriseta Smith, Trans. Amer. Microsc. Soc. 45: 180, pl. 12, figs. 5—9. 1926.

Type locality: Leipzig, Germany.

CHODATELLA SUBSALSA Lemm., Hedwigia 37: 310. 1998.

Lagerheimia subsalsa Lemm., Forsch. d. Biol. Stat. i. Plon. 6: 28, pl. 5, figs. 2—6. 1898.

Type locality: Germany.

CHODATELLA WOLOSZYNSKAE (Woloszynska), comb. nov.

Chodatella subsalsa var. *citriformis* Woloszynska, Hedwigia 55: 201, pl. 7, figs. 15—19. 1914.

Lagerheimia citriformis var. *paucispina* Tiffany and Ahlstrom, Ohio Jour. Sci. 31: 462. 1931.

This species should be compared with *Chodatella subsalsa* and *Chodatella citriformis*. It differs from the former in having the cell of lemon-shape, and from the later in having three to four setae at each pole.

Type locality: East Africa.

The author's grateful thanks are due to Dr. C. C. Jao for the advice and criticisms and to Dr. S. C. Teng for his kind suggestions and also to Professor Wm. R. Taylor of Michigan University, U.S.A. for supplying microfilms of some of the literature.

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STUDIES ON THE FRESHWATER ALGAE OF CHINA
XVIII. SOME FRESHWATER ALGAE FROM CHENGKU, SHENSI

CHIN-CHIH JAO

The samples of the freshwater algae dealt with in the present communication were collected by Messrs. L. F. Yen and S. S. Mao of the National Northwestern University, to whom the writer is much obliged for their generous cooperation. The total number of this collection is fifty-two. No field notes for each sample have been taken by the collectors; they simply noted that these samples were gathered either from the rice fields or from the shallow ponds in the suburb of Chengku, Shensi, during the period from August to November in 1944. According to this note, there are no subaerial algae present in these samples.

Nothing is previously known regarding the algal flora of the Shensi province. In this paper, 132 species, 27 varieties, and 5 forms are listed. Most of them commonly occur in different localities of southwestern China. The occurrence of some species, such as *Phormidium Bohneri, Anabaena Volzii, Aulosira laxa, Microchaete uberrima, Calothrix brevissima, Oedogonium obtruncatum* var. *completum* and *Pleurotaenium elatum* f. *duplo-major,* indicates that the algal flora of this district seems to be closely related to that of the Indo-Malayan region. Some others, such as *Chamaesiphon clavata, Scytonema incrassatum, Pediastrum duplex* var. *echinatum, Oedogomium spiralidens,* and *Spirogyra subpolytaeniata,* show that algae endemic in Hunan, Kwangsi, and Szechwan are also distributed in southern Shensi. As we know that the Chengku district is located between two high mountain ranges, viz., Tsingling and Tapashan, both extend from west towards east. The second range seems to be a boundary preventing the distribution of some endemic algae of southwest China and Indo-Malayan regions to the north. But, in fact, this is not true.

In these samples, only the species belonging to the Myxophyceae, Chlorophyceae, Heterocontae, Bacillarieae, and Euglenieae are present; and those belonging to other groups are entirely wanting. At present, the writer's work is confined to the Myxophyceae, Chlorophyceae, and Heterocontae. The remaining two groups will not be undertaken due to some difficulties in determination.

In this paper, eleven new species, viz., *Lyngbya Cladophorae, Anabaena shensiensis, Nostoc shensiense, Aulosira confluens, Coelastrum shensiense, Scenedesmus polycostatus, Scenedesmus shensiensis, Bulbochaete nitida, Cladophora shensiensis, Zygnema shensiense,* and *Cosmarium subsecuriforme,* and seven new varieties, viz., *Oscillatoria tenuis* var. *shensiensis, Lyngbya Bergei* var. *tenuior, Nostoc spongiaeforme* var. *regulare, Oedogonium fragile* var. *subdepressum, Oedogonium intermedium* var. *breviarticulatum, Oedogonium oblongum* var. *polymorphum,* and *Staurastrum margaritaceum* var. *elegans,* are described. Type specimens of these new algae are kept in the Herbarium of the Institute of Botany, Academia Sinica.

MYXOPHYCEAE

Chroococcaceae

Aphanocapsa elachistria W. et G. S. West var. planctonica Smith—*SS23*, rare.

The colonies of the Chinese plants are usually obovoid but more or less irregular in outline, mostly free floating, and sometimes attached to other filamentous algae. The cells are spherical, loosely arranged, 1.8—2.7 μ in diameter, and with grey and homogeneous contents.

This variety has not previously been recorded from China.

Aphanocapsa pulchra (Kuetz.) Rabenh.—*SS49*, fairly scarce.

Aphanothece pallida (Kuetz.) Rabenh.—*SS47*, common.

In the present sample, the colonies of this species are mostly larger in size and irregular in shape. The periphery of the colonial envelope is mostly yellowish to yellowish brown and gradually becomes colorless towards interior. In the colored portion, the individual sheaths of the cells are usually distinct and may or may not show conspicuous stratifications. The cells are 6.3—7.2 μ in diam. and 9.0—13.5 μ long.

This species has not previously been recorded from China.

Aphanothece stagnina (Spreng.) A. Br.—*SS22* & *46*, fairly common.

The colonies of the Chinese plants are subglobose in shape and up to 165 μ in diameter. The cells are 3.5—4.5 μ in diameter and 5.4—7.2 μ long. The cell contents are pale blue-green and homogeneous.

In China, this species has previously been recorded only from Yunnan.

Chroococcus limneticus Lemm.—*SS52*, scarce.

Chroococcus limneticus Lemm. var. subsalsus Lemm.—*SS52*, fairly scarce.

This species differs from its type species chiefly in having much smaller cells. In the present sample, the cells of this alga without sheath are 3.5—4.5 μ in diameter, and with sheath are 4.5—5.5 μ in diameter. A single colony contains mostly 16—32 cells and is nearly spherical in shape.

This variety has not previously been recorded from China.

Chroococcus turgidus (Kuetz.) Naeg.—*SS21*, rare.

Coelosphaerium dubium Grun.—*SS21*, fairly common.

Merismopedia punctata Meyen—*SS2*, rare.

Microcystis flos-aquae (Wittr.) Kirchn.—*SS21*, fairly common.

Microcystis ichthyoblabe Kuetz.—*SS46*, scarce. (Fig. 1, *g*)

In the present sample, the larger colonies of this species are usually irregular in shape and contain a number of spherical or obovoid sub-colonies. Each sub-colony has its own envelope which is usually confluent with the colonial envelope. The cells are spherical, with pseudovacuoles, 2—3 μ in diameter, and close together. These characteristics show that the present specimens are a typical form of this species.

This species seems to be an uncommon alga. It has not previously been recorded from China.

Microcystis pallida (Farlow) Lemm.—*SS46*, scarce.

This species should be compared with *M. flos-aquae* (Wittr.) Kirchn., but differs from it chiefly in having colonies irregular in shape, gelatinous envelope thicker but not very distinct, and cell contents without pseudovacuoles.

PLEUROCAPSACEAE

XENOCOCCUS SCHOUSBOEI Thur.—*SS36*, common.

This species found in this sample is epiphytic on *Zygnema*. Its colonies are either solitary or often grouped into one-cell thick strata without a definite shape and surrounding the filaments of the host. The cells are typically spherical, but become angular by mutual compression. Each cell is sheathed by a conspicuous individual sheath which is usually pale yellowish and homogeneous in structure. In some cases, the individual sheaths are confluent with one another to form a somewhat watery and gelatinous colonial envelope. The cells are very variable in size, from 5 to 10 μ in diam., and with blue-green and granular contents. The multiplication cells, which form the endospores, are, as a rule, comparatively deeply colored.

This is one of the mraine species of this genus, but has also been found in freshwaters in North America. It is new to China.

CHAMAESIPHONACEAE

CHAMAESIPHON CLAVATUS Jao—*SS2* & *26*, scarce.

This species was described by the writer from Hunan in 1939, and was again found by him from Kwangsi and Szechwan in successive years. It is very interesting that this alga is now discovered in southern Shensi.

OSCILLATORIACEAE

LYNGBYA AERUGINEO-AERULEA (Kuetz.) Gom.—*SS26*, fairly common.

In the present sample, the dimensions of this species are: filaments 4.5—6.0 μ in diameter; trichomes 4.5 μ in diameter; cells mostly 2.5—3.5, sometimes up to 5 μ long. The cross walls below the end portion of the trichomes are usually indistinct.

LYNGBYA BERGEI Smith var. TENUIOR, var. nov.—*SS22*: *B*, scarce; *SS25* (TYPE), fairly common; *SS32*, rare. (Fig. 1, *a*)

Var. filamentis 21—25 μ latis; vaginis dilute luteis, 2—3 μ crassis; trichomatibus ad genicula passim leviter constrictis, 17—19 μ latis; cellulis 2.0—5.5 μ longis; cellula apicali ad 10 μ longa; ceterum ut in forma typica.

According to the diagnosis of this species given by G. M. Smith in his Phytoplankton of the Inland Lakes of Wisconsin, Part I, p. 54, the trichomes are "without constrictions at the cross walls." One of his drawings given in the same book, viz., pl. 7, fig. 15, shows the constrictions quite distinctly, and the other, viz., pl. 7, fig. 14, not. In the present sample, the alga considered by the writer as a variety of this species is characterized by its trichomes distinctly but slightly constricted at some of their cross walls. Furthermore, this variety has narrower trichomes and pale yellow sheaths.

LYNGBYA CLADOPHORAE, sp. nov.—*SS35*: *B* (TYPE), common. (Fig. 1, *b*)

L. filamentis rectis vel flexuosis, medio adfixis, utrinque erectis, plerumque in fasciculos parvos aggregatis, ad 500 μ longis, 2.4 μ latis; vaginis tenuibus, hyalinis, arctis, papyraceis; trichomatibus ad genicula non constrictis, 1.8 μ latis, apice non attenuatis; cellulis diametro trichomatis 0.5-plo brevioribus vel aequalibus, 0.9—1.8 μ longis; dissepimentis pellucidis, non granulatis; contentu homogeneo et pallide aerugineo; cellula apicali superne obtuse rotundata, non capitata nec attenuata.

This species should be compared with *L. Nordgardhii* Wille and *L. Polysiphoniae* Frémy, but differs from them chiefly in having trichomes not constricted at the cross walls.

LYNGBYA MAJOR Menegh.—*SS8, 13, 18,* & *20,* scarce.

In these samples, the dimensions of this alga are variable. In samples *8* and *20:* filaments 14.5—16 μ in diameter, cells 11.5—13.5 μ in diameter, 1.5—2.7 μ long; apical cell up to 4.5 μ long; sheaths up to 2.7 μ thick. In sample *18*: filaments 17—19 μ in diameter; cells 13—14 μ in diameter, 1.0—3.6 μ long; sheaths 2.0—2.5 μ thick. In sample *13:* filaments 20—22 μ in diameter; cells 14—16 μ in diameter, 2.7—3.6 μ long; sheaths up to 3.5 μ thick.

MICROCOLEUS LACUSTRIS (Rabenh.) Farlow—*SS47,* rare.

In the present sample, the apical cell of the Chinese plants is not regular in shape. It may be either cylindrical and with a rounded apex or more or less conical and with an obtuse end. A single filament mostly contains more than 10 trichomes which are almost entirely parallel to each other. Other characteristics are, however, quite typical.

OSCILLATORIA BRLVIS (Kuetz.) Gom.—*SS8,* rare; *SS49* & *51,* common.

In these samples, the trichomes of this species are mostly solitary, rarely with a curved apex, and sometimes slightly constricted at some of their cross walls.

OSCILLATORIA CORTIANA Menegh.—*SS8,* scarce; *SS21,* fairly common.

The trichomes of the Chinese plants are 4.5—5.5 μ in diameter. The cells are 6.5—12.0 μ long and mostly two times or, sometimes, a little longer than broad. As compared with the dimensions of those of the typical form, the Chinese plants have a little narrower but proportionally longer cells.

This species has not previously been recorded from China.

OSCILLATORIA FORMOSA Bory—*SS21,* scarce.

OSCILLATORIA PRINCEPS Vauch.—*SS6* & *22,* rare; *SS21, 38: B, 49,* & *51,* scarce; *SS18,* fairly common.

In sample *18,* the trichomes are 63—65 μ in diameter; in the others, they are less than 50 μ in dimeter. The larger ones may be considered as a form, ***maxima,*** ot this species as listed in Rabenhorst's Flora Europaea Algarum, Vol. 2, p. 112, 1865.

OSCILLATORIA SUBAMOENA Jao—*SS49* & *51,* fairly scarce. (Fig. 1, *d*)

This species was described by the writer from the suburb of Lanchow, Kansu, in 1947 (Bot. Bull. Acad. Sinica 1: 70. 1947). This is its second discovery.

OSCILLATORIA TENUIS Ag.—*SS34, 37,* & *42,* scarce.

OSCILLATORIA TENUIS Ag. var. NATANS (Kuetz.) Gom.—*SS2,* scarce.

The trichomes of the Chinese plants are either straight throughout their entire length or more or less flexuous at middle portion, up to 1240 μ long, slightly constricted at the cross walls, and 6.0—7.5 μ in diameter. The cells are 3.5—5.5 μ long and with blue-green and granular contents.

OSCILLATORIA TENUIS Ag. var. SHENSIENSIS, var. nov.—*SS42: B* (TYPE), fairly rare. (Fig. 1, *c*)

Var. trichomatibus solitariis, ad genicula passim constrictis, 7.0—7.5 μ latis; cellulis diametro trichomatis aequalibus vel paullo longioribus aut brevioribus, 4.5—9.0 μ longis; ceterum ut in forma speciei typica.

PHORMIDIUM AMBIGUUM Gom.—*SS45,* fairly common.

The characteristics of the Chinese plants agree in all respects with those of a typical form.

This species has not previously been recorded from China.

PHORMIDIUM BOHNERI Schmidle—*SS37,* fairly common.

This species is known previously to be a subaerial alga found on damp ground only in Africa and India. In the present sample, the alga referred to this species is an aquatic form, but its other characteristics are entirely identical to Schmidle's diagnosis of this species (Engl. Bot. Jahrb. 30: 59. 1901). Probably, this species inhabits not only on damp ground. The dimensions of the Chinese plants are: trichomes 1.8—2.0 μ in diameter; cells 0.9—2.7 μ long, mostly shorter than broad.

This species has not previously been recorded from China.

PHORMIDIUM FAVOSUM (Bory) Gom.—*SS37,* common.

The dimensions of the Chinese plants are: trichomes 4.5—5.5 μ in diameter; cells 4.5—7.2 μ long.

In China, this species has previously been recorded only from Hunan and Sikang.

SPIRULINA MAJOR Kuetz.—*SS15* & *20* scarce.

NOSTOCACEAE

ANABAENA INAEQUALIS (Kuetz.) Born. et Flah.—*SS13,* common; *SS42,* scarce.

In the present samples, this alga is epiphytic on *Microchaete uberrima, Lyngbya major* and *Aulosira confluens.* Its trichomes are usually sheathed and 4.5—5.5 μ in diameter. Its cells are 2.7—4.5 μ long. Its heterocysts are globose or subglobose and 5.5—7.0 μ in diameter. The spores are always remote from the heterocysts, cylindrical, 5—6 μ in diameter, and 12—18 μ long.

In China, this species has previously been recorded only from Hunan and Yunnan.

ANABAENA SHENSIENSIS, sp. nov.—*SS8* (TYPE), scarce, (Fig. 1, *e*)

A. trichomatibus tenuissime vaginatis, solitariis, inter alias algas sparsis, rectis vel leviter curvatis, dilute aerugineis, 3.6—4.0 μ latis, ad genicula distincte constrictis, apices versus levissime attenuatis; cellula apicali obtuso-conica; cellulis cylindricis, plerumque diametro trichomatis 2-plo longioribus, 5.5—9.0 μ longis; heterocystis cylindricis, apicibus truncato-rotundatis, 5.4—6.3 μ latis, 7—9 μ longis; sporis singlis, heterocystis utrinque late rotundatis, 10—14 μ latis, 18—23 μ longis, membrana laevi, maturitate fuscescente.

Attention may be drawn to some resemblance between this species and *A. mediocris* Gardn. and *A. Volzii* Lemm., but they are clearly distinguished from each other by the form of heterocysts and the form, color, and dimensions of spores.

ANABAENA VOLZII Lemm.—*SS8, 18,* & *19,* scarce; *SS20,* common. (Fig. 1, *f*)

The writer believes he is right in referring the material in these samples to this little-known species, which has previously been recorded only from Java and Singapore by Lemmermann in 1904 (Abh. Nat. Ver. Bremen 18: 153, pl. 11, figs. 4, 5, and 20. 1904). Based upon the characteristics of the Chinese plants, a full description of this species is given as follows:

Plants free floating, mostly solitary, rarely aggregated by few individuals; sheaths not present; trichomes distinctely constricted at the cross walls, more or less flexuous, 4—5 μ in diameter; apical cell obtuse conical; cells cylindrical, 7—13 μ long, mostly

nearly 2 times longer than broad; cell contents pale blue-green, finely granular, without pseudovacuoles; heterocysts cylindrical, truncate at the apices, 5.5—7.0 μ in diameter, 10—14 μ long; spores ellipsoid, always single and contiguous to the heterocysts, 13—17 μ in diameter, 27—36 μ long, with coarsely granular centents and a smooth and colorless wall at maturity.

This species should be compared with *A. Levanderi* Lemm., which has the spores remote from the heterocysts, obovoid in shape, and more variable in dimensions. These two species are, however, closely allied.

CYLINDROSPERMUM MAJUS Kuetz.—*SS32,* fairly common.

NODULARIA HARVEYANA Thur. var. SPHAEROCARPA (Born. et Flah.) Elenk.—*SS36,* scarce.

Only the vegetative filaments of this variety are present in this sample. They are solitary and enclosed by a diffluent sheath. The trichomes are 6.0—6.5 μ in diameter and not distinctly tapering at the ends. The cells are 2.7—4.5 μ long. The heterocysts are 8—9 μ in diameter and 4.5—6.5 μ long. These characteristics indicate that these plants should be referred to this variety.

This variety has not previously been recorded from China.

NODULARIA SPUMIGENA Mertens in Juergens—*SS2, 34,* & *42,* scarce.

Cells 9—10 μ in diameter, 1.8—3.6 μ long; heterocysts 12—13 μ in diameter, 4.5—6.5 μ long.

NOSTOC CARNEUM Ag.—*SS21,* rare. (Fig. 1, *h*)

The characteristics of the Chinese plants are entirely identical with the diagnosis given in Sylloge Algarum (5: 395. 1907). The cells are merely oblong cylindrical in form, and not "fast kugelig, tonnenförmig" as described by Geitler in Rabenhorst's Kryptogamen-Flora, Band XIV, Cyanophyceae, p. 139, 1932. Their dimensions are: cells 3.5—4 μ in diameter, 5.4—13.5 μ long, mostly 2 to 2.5 times longer than their broad; heterocysts 6 μ in diameter, 6—13 μ long; spores 5.5—6.5 μ in diameter, 9—15 μ long.

In China, this species has previously been recorded only from Yunnan.

NOSTOC CUTICULARE (Bréb.) Born. et Flah.—*SS5* & *21,* scarce.

The plant mass of the Chinese plants is very thin, mostly composed of a single layer of filaments which are more or less parallel to each other and densely compacted. The cells are 3.6—4.5 μ in diameter and long. The heterocysts are 4.5—5.5 μ in diameter and 5.5—6.5 μ long.

This species has not previously recorded from China.

NOSTOC PALUDOSUM Kuetz.—*SS8,* scarce.

Cells 3 μ in diameter, 2.7—3.6 μ long; heterocysts 3.6—4.5 μ in diameter; spores 3.6—4.5 μ in diameter, 4.5—7.2 μ long.

NOSTOC SHENSIENSE, sp. nov.—*SS9* (TYPE), common. (Fig. 1, *j*)

N. thallis aquaticis, libere natantibus, membranaceis, tenuibus, indefinite expansis, gelatinosis, viridi-aerugineis vel fuscescentibus; trichomatibus flexuoso-curvatis, dense intrictis; cellulis subglobosis vel depresso-globosis, 4.5—5.5 μ latis, 3.5—4.5 μ longis; cententu aerugineo et granuloso; heterocystis subglobosis vel globosis, solitariis, 5.5—7.0 μ latis, hyalinis; sporis globosis vel subglobosis, 7.5—10 μ latis, in longas catenas seriatis, approximatis, membrana laevi, crassa, hyalina.

This species should be compared with *N. piscinale* Kuetz. and *N. calidarium* Wood, an incompletely described species. It differs from the first chiefly in having membranous thalli and larger cells; and from the second chiefly in having thalli not neatly laciniate.

NOSTOC SPHAERICUM Vauch.—*SS22,* scarce.

NOSTOC SPONGIAEFORME Ag.—*SS32* & *47,* fairly common.

Vegetative cells 4.5—5.0 μ in diameter, 4.5—7.2 μ long; heterocysts 6.3—7.2 μ in diameter; spores 5.4—6.3 μ in diameter, 9—11 μ long.

This species has not previously been recorded from China.

NOSTOC SPONGIAEFORME Ag. var. REGULARE, var. nov.—*SS15* (TYPE) abundant. (Fig. 1, *i*)

Var. cellulis regulariter depresso-globosis vel doliiformibus, 4.5—5.5 μ latis, 3.5—5.5 μ longis; heterocystis 6—8 μ latis; sporis transverse obovoideis, 7—11 μ latis, 6—8 μ longis; ceterum ut in forma speciei typica.

SCYTONEMATACEAE

AULOSIRA CONFLUENS, sp. nov.—*SS13* (TYPE), common. (Fig. 2, *d*)

A. strato membranaceo, late expanso, olivaceo; filamentis subrectis vel interdum irregulariter flexuosis, plerumque parallelis, rarissime brevissime pseudo-ramosis, (9-) 11—16 μ latis; vaginis crassissimis, superfacie erosissimis et interdum diffluentibus, hyalinis, indistincte lamellosis, semper in stratum confluentibus; trichomatibus ad genicula constrictis; cellulis vegetativis 4.5—5.5 μ latis, 4.5—10 μ longis, plerumque diametro 2-plo longioribus; dissepimentis plerumque plus minusve inconspicuis; contentu granuloso et pallide aerugineo; heterocystis oblongis vel quadratis, 4.5—6.5 μ latis, 5.5—9.0 μ longis; cellula apicali obtuse conica; sporis catenatis, cylindraceo-obovoideis vel subrectangularibus, 7—10 μ latis, 6—18 μ longis, regulariter cum cellulis abbreviatis moribundis deplanatis alternantibus, membrana dilute lutea et laevi.

A. fertilissima Ghose is closely allied to this species, but the dimensions of the first are much greater than those of the second.

AULOSIRA LAXA Kirchn.—*SS5, 15, 20, 21, 39* & *44,* all common.

Filaments 6—8 μ in diameter; cells 4.5—6.5 μ in diameter, 6.5—9.0 μ long; heterocysts 6.5—9.0 μ in diameter, 6.5—16 μ long; spores 7—8 μ in diameter, 13—23 μ long.

This species has not previously been recorded from China, but has been found by the writer in several localities in Szechwan.

MICROCHAETE UBERRIMA Carter—*SS13, 18, 23,* & *25,* fairly common; *SS21,* scarce.

This alga was described by Carter from India in 1926 and has also been recorded by the writer from Hunan in 1939. Since then the writer has discovered it in different localities in Kwangsi and Szechwan. It seems to be a common species of this genus distributed in southwestern China.

In sample *18,* this alga is smaller than its typical form, but larger than *M. uberrima* Carter f. *minor* Carter. Its dimensions are: filaments 13 in diameter, cells 9 μ in diameter, 4.5—15 μ long; basal heterocysts 11—12 μ in diameter; intercalary heterocysts 11—12 μ in diameter, 16—32 μ long; spores 12 μ in diameter, 13—36 μ long.

SCYTONEMA CRISPUN (Ag.) Born.—*SS36*, common.

The sheaths of the Chinese plants are either colorless or partly colored and with a more or less roughened surface. The colored portions are usually clearly separated into a thinner, colorless outer layer and a thicker, yellowish brown inner layer.

SCYTONEMA INCRASSATUM Jao—*SS4* & *46*, fairly common.

This species was described by the writer from Kwangsi in 1944 (Sinensia 15: 84, pl. 2, fig. 4. 1944). This is its second discovery. The characteristics of the present specimens agree in all respects with those from Kwangsi, except that the Kwangsi plants grow on damp ground.

TOLYPOTHRIX DISTORTA Kuetz. var. PENICILLATA (Ag.) Lemm.—*SS4, 21, 22, 23*, fairly common.

Dimensions of this alga are variable. In the present samples, its dimensions are: filaments 12—15 μ in diameter; sheaths up to 4 μ thick; trichomes 6—8 μ in diameter; cells 4.5—7.0 long; heterocysts 8—12 μ in diameter, 12—19 μ long.

RIVULARIACEAE

CALOTHRIX BREVISSIMA G. S. West—*SS47*, common.

In the present sample, the filaments of this alga are always documbent on other filamentous algae throughout their entire length, rarely solitary, mostly aggregated and parallel to each other, usually straight or sometimes a little curved, and 6—7 μ in diameter. The sheaths are very thin, colorless and firm. The trichomes may or may not be constricted at all or a part of the cross walls. As a rule, the apex of the trichomes is not ending in a hair but only a little attenuated. The cells are 4.5—5.5 μ in diameter and 2.5—4.5 μ long. The heterocysts are mostly solitary, very rarely two or three, 4.5—5.5 μ in diameter, and colorless.

The plant with the trichome constricted at all cross walls is usually the young one. That with the trichome only constricted at a part of its cross walls is the oldest one, which is usually characterized by forming the hormogones.

This species was first described by G. S. West from Africa in 1907 (Jour. Linn. Soc. London, Bot. 38: 180, pl. 10, fig. 8, 1907). In his original description, he did not mention the constriction of the trichomes at the cross walls. Judging from his drawing, all trichomes show no constrictions at the cross walls. In 1927, Ghose described a variety, *moniliforma* (should be called *moniliformis*), of this species from Burma (Jour. Burma Res. Soc. 17: 242, pl. 2, fig. 13. 1927). This variety differs from its type species in having barrel-shaped cells. According to the writer's investigation of the Chinese plants, the constriction of trichomes at the cross walls is certainly not a constant character of this species. Thus Ghose's variety seems to be better considered as a synonym of this species.

CALOTHRIX STAGNALIS Gom.—*SS13* & *23*, scarce; *SS75* & *36*, fairly common.

The sheaths of the Chinese plants may be either papery in all developmental stages or becoming very thick and gelatinous with age.

GLOEOTRICHIA NATANS Rabenh.—*SS8, 10, 19,* & *20*, all common.

GLOEOTRICHIA PISUM Thur.—*SS21*, common.

CHLOROPHYCEAE

Volvocaceae

Eudorina elegans Ehr.—*SS52*, fairly scarce.
Chlamydomonas gloeocystiformis Dill.—*SS50*, scarce; *SS52*, abundant.

This species has not previously been recorded from China.

Chlamydomonas Snowiae Printz—*SS52*, fairly common.
Pandorina Morum (Muell.) Bory—*SS42*, rare.
Volvox aureus Ehr.—*SS10*, common; *SS18*, rare.

Tetrasporaceae

Tetraspora gelatinosa (Vauch.) Desv.—*SS48*, common.
Tetraspora lacustris Lemm.—*SS21*, fairly common.

Young colonies of this alga, which contain four or eight cells, are mostly attached to other filamentous algae. The larger ones are always free floating.

Pamellaceae

Gloeocystis ampla Kuetz.—*SS4* & *22*, fairly common; *SS15*, rare.
Gloeocystis gigas (Kuetz.) Lagerh.—*SS5*, *21*, & *23*, scarce; *SS22*, fairly common.
Sphaerocystis Schroeteri Chordat—*SS42*, scarce.

Hydrodictyaceae

Hydrodictyon reticulatum (L.) Lagerh.—*SS2*, *6*, *12*, & *38*: *B*, common.
Pediastrum duplex Meyen var. echinatum Jao—*SS21*, rare.

This variety was described by the writer from Kwangsi in 1947 (Bot. Bull. Acad. Sinica 1: 247, fig. 3, *k*). This is the second discovery.

Pediastrum tetras (Ehr.) Ralfs.—*SS2* & *15*, rare.
Sorastrum spinulosum Naeg.—*SS21*, *22*, & *23*, rare.

Oocystaceae

Nephrocytium Agardhianum Naeg.—*SS4*, *8*, & *21*, rare.
Nephrocytium Naegelii Grun. in Rabenh.—*SS22* & *23*, scarce.

Colonies subglobose or nearly so, 50—68 µ in diameter; cells kidney-shaped, 13.5—1.5 µ in diameter, 22—25 µ long.

This species has not previously been recorded from China.

Oocystis solitaria Wittr.—*SS4*, *5*, *22*, & *25*, rare.

The dimensions of the cells of the Chinese plants are 8—13 µ in diameter and 15—20 µ long. This is a small form of this species, and, judging from its size, is nearest to *O. solitaria* Wittr. var. *apiculata* (W. West) Printz.

Tetraedron bifurcatum Lagerh.—*SS21*, scarce.

Coelastraceae

Ankistrodesmus falctus (Corda) Ralfs—*SS2*, *15*, & *21*, rare.
Caelastrum microporum Naeg.—*SS5*, *18*, & *37*, rare.
Coelastrum proboscideum Bohlin—*SS46*, rare. (Fig. 3, *i*)
Coelastrum shensiense, sp. nov.—*SS21*: B (type), *22*, & *46*, rare. (Fig. 3, *h*)

C. coenobiis sphaericis, 16- vel 32-cellularibus, ad 94 μ latis; cellulis aspectu polari exacte hexagoniis, medio marginis exterae plus minusve distincte umbonatis, 23—27 μ latis, 20—23 μ crassis; membrana crassissima, distincte lamellosa, ad 5.5 μ crassa; areolis regulariter triangularibus, parvis.

This species should be compared with *C. sphaericum* Naeg., but differs from the latter in having regularly triangular interstices and in that the cells are much larger in size, regularly hexagonal in polar view, thick-walled, and more or less distinctly umbonate at the centre of their outer side.

DIMORPHOCOCCUS LUNATUS A. Br.—*SS21*, fairly scarce.

SCENEDESMUS ABUNDANS (Kirchn.) Chod.—*SS37*, fairly common.

SCENEDESMUS BIJUGA (Turp.) Lagerh.—*SS37*, scarce.

SCENEDESMUS BREVISPINA (Smith) Chod.—*SS37*, fairly common.

The coenobia of the Chinese plants are either 2- or 4-celled. The cells are 3.5—4.5 μ in diameter, 8—11 μ long, and mostly with 1 or sometimes 2 short spines on both poles.

This species has not previously been recorded from China.

SCENEDESMUS DENTICULATUS Lagerh. var. LINEARIS Hansgr.—*SS15, 18,* & *21,* scarce.

The cells of the Chinese plants are 4.5—6.3 μ in diameter, 11—14 μ long, and with 2—3 short spines on both poles.

This variety should be compared with the preceding species, which has smaller cells and mostly with only a single short spine on each pole.

This variety has not previously been recorded from China.

SCENEDESMUS DIMORPHUS (Turp.) Kuetz.—*SS37*, scarce.

SCENEDESMUS OBLIQUUS (Turp.) Kuetz.—*SS37*, rare.

SCENEDESMUS PLATYDISCUS (Smith) Chod.—*SS21*, fairly rare.

SCENEDESMUS POLYCOSTATUS, sp. nov.—*SS37*: *C* (TYPE), fairly scarce. (Fig. 3, *k*)

S. coenobiis curvatis, e cellulis 8 arcte conjunctis in seriem duplicem dispositis constitutis; cellulis ellipsoideis vel subhexangularibus, apice mucronato-apiculatis, 5.5—7.5 μ latis, 11—12 μ longis, membrana parte libera per 10—14 costis prominentibus percursa, lines ad apices convergentibus, sectione optica transverali undulato-orbiculata.

This species should be compared with *S. costatus* Schmidle, but differs from the latter chiefly in having coenobia regularly composed of two rows of cells which are not polygonal in end view and are furnished with 10—14 longitudinal ribs.

SCENEDESMUS QUADRICAUDA (Turp.) Bréb.—*SS37*, rare.

SCENEDESMUS SHENSIENSIS, sp. nov.—*SS37*: *B* (TYPE), common. (Fig. 3, *j*)

S. coenobiis e cellulis 4 vel 8 in seriem linearem arcte conjunctis constitutis; cellulis omnibus cylindraceo-obovoideis, polis rotundatis, 3—5 μ latis, 11—13 μ longis, extimis utroque polo aculeolatis, medianis in uno polo aculeolatis et in cetero breviter dentatis; aculeis ad 10 μ longis.

This species seems to be closely allied to *S. longus* Meyen var. *Naegelii* (Bréb.) Smith, but differs from the latter in having much smaller cells and having interior cell of the coenobia with a long spine at one pole and a short tooth at the another. It should also be compared with *S. elliptica* (W. et G. S. West) Chod., which has larger, ellipsoid cells and only a long spine at one pole of the interior cells.

ULOTRICHACEAE

ULOTHRIX TENERRIMA Kuetz.—*SS34*, fairly common.
ULOTHRIX VARIABILIS Kuetz.—*SS2* & *18*, scarce; *SS42*, fairly common.
SCHIZOMERIS LEIBLEINII Kuetz.—*SS2* & *29*, scarce; *SS3, 5, 6, 7, 12, 35, 41*, & *45*, common.

CHAETOPHORACEAE

CHAETOPHORA ELEGANS (Roth) Ag.—*SS21*, rather scarce.
PROTODERMA VIRIDE Kuetz.—*SS21*, rare.
STIGEOCLONIUM NANUM Kuetz.—*SS26*, rare.

Only a few individuals of this alga are present in this sample. Their dimensions are: thalli 0.5—1 mm. tall; cells of main filaments 10—13 μ in diameter and 7—13 μ long; cells of main branches 7—10 μ in diameter and 5—13 μ long; cells of ramuli 4.5—6.5 μ in diameter and 8—14 μ long.

STIGEOCLONIUM sp. — *SS41*, fairly common.

Only young plants are present in this sample.

CHAETOPELTIDACEAE

CHAETOSPHAERIDIUM GLOBOSUM (Nordst.) Kleb.—*SS4* & *21*, rare.

APHANOCHAETACEAE

APHANOCHAETE REPENS A. Br.—*SS26*, scarce.

COLEOCHAETACEAE

COLEOCHAETE SCUTATA Bréb.—*SS21*, rare.

CYLINDROCAPSACEAE

CYLINDROCAPSA GEMINELLA Wolle—*SS4, 21, 22, 23, 25* & *04*, scarce.

OEDOGONIACEAE

BULBOCHAETE NITIDA, sp. nov.—*SS21*: *C* (TYPE), rare. (Fig. 2, *e - g*)

B. monoica, plerumque breviter et paucissime ramosa; cellulis vegetativis submoniliformibus vel subcylindricis; oogoniis suboblongo-ellipsoideis vel interdum subobovoideis, erectis, sub setis terminalibus vel interdum sub cellulis vegetativis sitis; dissepimento cellularum suffultoriarum superiore, oblique constituto; cellula suffultoria superiori parvissima, a latere visa subtriangulari, a fronte visa semicirculari; oosporis oogonia conformantibus et plerumque subtus vix complentibus; membrana oosporae crassa et triplici; episporio laevi et tenui; mesosporio crasso et longitudinaliter costato (in sectione optica transversali dentato-undulato), costis plerumque anastomosantibus, dense et longe dentatis, in medio oosporae 22—28, inter se transverse costulatis; antheridiis 1- vel 2-cellularibus, patentibus vel raro erectis et intercalaribus, sparsis; spermatozoidiis binis, divisione horizontali.

Cell. veg.	15—20 μ diam., 17—25 μ long.
Oogonia	30 μ diam., 45—50 μ long.
Oosporae	28 μ diam., 43—45 μ long.
Antheridia	9—10 μ diam., 5— 9 μ long.

Two peculiar facts are evident in this species. First, the upper suffultory cell is practically a small part of the oogonium. From the youngest oogonium, we may trace out that this suffultory cell is formed after the oogonium has already been partitioned off from the suffultory cell below. Second, the antheridia may be formed intercalarily between the vegetative cells of certain lower portions of the main filaments and branches. As we know that the antheridia developing in such a position has not been found in all previously described species of *Bulbochaete,* and is, however, of ordinary occurrence in all monoecious and dioecious-macrandrous species of *Oedogonium.*

This is the only known species of this genus possessing a smooth epispore and a mesospore with densely toothed ribs which are connected by transverse lines to form a reticulum. In size, it seems to be related to *B. monile* Wittr. et Lund., *B. Debaryana* Wittr. et Lund., and *B. mirabilis* Wittr. It differs from them collectively in having different characteristics of spore wall and peculiar upper suffultory cell.

In 1938, R. N. Singh described an Indian *Bulbochaete, B. Bharadwajai* (Proc. India Acd. Sci. 8: 395, fig. 10, D. 1938). Judging from his drawing the upper suffultory cell of *B. Bharadwajai* is similar to that of the Chinese species. However, the Indian species is nannandrous.

BULBOCHAETE spp.—*SS22,* & *46,* rare.

Only sterile filaments are present in these samples.

OEDOGONIUM CAPITELLATUM Wittr.—*SS23,* rare.

Veg. cells	5—7 μ diam., 13—30 μ long.
Oogonia	22—25 μ diam., 22—28 μ long.
Oospores	20—23 μ diam., 18—20 μ long.
Anth. cells	6 μ diam., 7 μ long.
Basal cells	13 μ diam., 10 μ long.

In the present sample, the oogonia of this species may occasionally be 2- or 3-seriate.

OEDOGONIUM CONFERTUM Hirn—*SS21,* fairly rare.

Veg. cells	20—27 μ diam., 50—75 μ long.
Oogonia	50—58 μ diam., 45—50 μ long.
Oospores	45—48 μ diam., 43—48 μ long.
Dwarf males	11 μ diam., 17 μ long.

This species seems to be very rare. Previously, it has only been recorded from Australia.

OEDOGONIUM CRASSUM (Hass.) Wittr. f. AMPLUM (Magn. et Wille) Wittr.—*SS40,* common.

Veg. cells, female plants	42—58 μ diam., 92—180 μ long.
Veg. cells, male plants	37—45 μ diam., 75—175 μ long.
Oogonia ..	75—87 μ diam., 82—105 μ long.
Oospores	70—83 μ diam., 75— 85 μ long.
Antheridia	35—45 μ diam., 5— 10 μ long.

OEDOGONIUM CRENULATOCOSTATUM Wittr.—*SS18,* fairly common.

Veg. cells, female plants	13—15 μ diam., 45—90 μ long.
Veg. cells, male plants	12—13 μ diam., 45—90 μ long.
Oogonia	35—37 μ diam., 70—83 μ long.
Oospores	30—33 μ diam., 45—50 μ long.
Antheridia	10 μ diam., 5— 8 μ long.

OEDOGONIUM CRISPUM (Hass.) Wittr. var. URUQUAYENSE Magn. et Wille—*SS21,* scarce.

Veg. cells	10—13 μ diam., 20—30 μ long.
Oogonia	30—33 μ diam., 30—33 μ long.
Oospores	28—30 μ diam., 28—30 μ long.
Antheridia	12 μ diam., 7— 8 μ long.

OEDOGONIUM CYATHIGERUM Wittr. f. PERFECTUM Hirn—*SS21,* rare.

Veg. cells	23—30 μ diam., 70—160 μ long.
Oogonia	65—71 μ diam., 65— 72 μ long.
Oospores	63—69 μ diam., 63— 70 μ long.
Sufflt. cells	48 μ diam., 72— 78 μ long.
Dwarf males	13 μ diam., 64— 68 μ long.

This plant has not previously been recorded from China.

OEDOGONIUM FRAGILE Wittr. var. SUBDEPRESSUM, var. nov.—*SS29*: *B* (TYPE), fairly scarce. (Fig. 2, *k*)

Var. cellulis vegetativis brevioribus; oosporis semper subdepresso-globosis, oogonia fere complentibus; antheridiis singulis; cellulis suffultoriis interdum subtumidis.

Cell. veg.	12—15 μ diam., 37—65 μ long.
Oogonia	42—47 μ diam., 42—50 μ long.
Oosporae	40—43 μ diam., 37—38 μ long.
Cell. suffult.	18—23 μ diam., 45—58 μ long.
Antheridia	12—13 μ diam., 8—13 μ long.
Cell. basales	15—16 μ diam., 50—65 μ long.

OEDOGONIUM INTERMEDIUM Wittr. var. BREVIARTICULATUM, var. nov.—*SS29*: *C* (TYPE), fairly common. (Fig. 2, *i, j*)

Var. cellulis vegetativis brevioribus, plerumque diametro 1.5-plo longioribus, antheridiis plerumque cum cellulis vegetativis alternantibus; oogoniis paullo latioribus.

Cell. veg.	15—22 μ diam., 15—50 μ long.
Oogonia	38—40 μ diam., 47—52 μ long.
Oosporae	35—36 μ diam., 35—36 μ long.
Antheridia	17—18 μ diam., 7—10 μ long.
Cell. basales	20—22 μ diam., 55—62 μ long.

The vegetative cells next to the basal cell are always longer and narrower than the upper ones. The upper cells rarely exceed 45 μ in length.

This variety should be compared with *Oedogonium intermedium* Wittr. var. *fennicum* Tiffany, but differs from the latter in having much shorter vegetative cells.

OEDOGONIUM NODULOSUM Wittr.—*SS22, 23,* & *46,* rare.

Veg. cells	.. .. 22—28 μ diam., 50—95 μ long.
Oogonia	48—53 μ diam., 58—70 μ long.
OOSPORES	46—50 μ diam., 48—53 μ long.
Antheridia	18—25 μ diam., 7— 9 μ long.

OEDOGONIUM OBLONGUM Wittr. var. POLYMORPHUM, var. nov.—*SS42*: *C* (TYPE), fairly common. (Fig. 2, *h*)

Var. oogoniis oosporisque majoribus; oosporis forma eiusdem filamentae variantibus, globosis, subglobosis vel obovoideis, oogonia non complentibus vel fere complentibus.

Cell. veg.	8—11 μ diam., 27—45 μ long.
Oogonia	28—32 μ diam., 36—47 μ long.
Oosporae	23—27 μ diam., 23—31 μ long.
Antheridia	8—11 μ diam., 4— 7 μ long.

OEDOGONIUM OBTRUNCATUM Wittr. var. COMPLETUM Hirn—*SS21*, scarce.

Veg. cells	15—23 μ diam., 43—137 μ long.
Oogonia	53—59 μ diam., 62— 75 μ long.
Oospores	50—57 μ diam., 60— 73 μ long.
Androsporangia	20—25 μ diam., 17— 20 μ long.

Lower cells of the filaments are always much narrower than the upper ones. The androsporangia are mostly either subepigynous or hypogynous and are rarely scattered.

Prof. Tiffany considered this variety as an independent species (Ohio Jour. Sci. 34: 326. 1934). As compared with its type species, this variety differs only in having somewhat larger oogonia and occasionally setiform apical cell of the filaments. Thus the writer agrees with Hirn in naming it as a variety.

This alga has previously been recorded only from Bengal.

OEDOGONIUM PRINGSHEIMII Cram. et Wittr.—*SS23* & *25*, fairly common.

Veg. cells, female plants	15—18 μ diam., 25—62 μ long.
Veg. cells, male plants	13—15 μ diam., 28—67 μ long.
Oogonia	32—37 μ diam., 25—62 μ long.
Oospores	30—35 μ diam., 30—35 μ long.
Antheridia	12—13 μ diam., 5— 8 μ long.

OEDOGONIUM PRINGSHEIMII Cram. et Wittr. var. NORDSTEDTII Wittr.—*SS21*, fairly scarce.

Forma oogoniis regulariter singulis; oosporis oogonia non complentibus, minoribus quam in forma typica.

Cell. veg. plant. fem.	15—20 μ diam., 30—63 μ long.
Cell. veg. plant. masc.	12—16 μ diam., 24—60 μ long.
Oogonia	35—40 μ diam., 37—43 μ long.
Oosporae	27—30 μ diam., 27—30 μ long.
Antheridia	10—15 μ diam., 6— 8 μ long.

OEDOGONIUM SPIRALIDENS Jao—*SS18*, rare.

Veg. cells	10—15 μ diam., 50—80 μ long.
Oogonia	47 μ diam., 45 μ long.
Oospores, with teeth	43 μ diam., 40 μ long.
without teeth	35 μ diam., 35 μ long.
Suffultory cells	30 μ diam., 50 μ long.

End of the filaments is mostly attenuated into a long, colorless, and 2- or 3-celled hair.

OEDOGONIUM TAPEINOSPORUM Wittr.—*SS15*, very rare.

Veg. cells	3— 5 μ diam., 10—30 μ long.
Oogonia	16—17 μ diam., 15—20 μ long.
Oospores	13—15 μ diam., 8—10 μ long.
Basal cell	13 μ diam., 7 μ long.

OEDOGONIUM UNDULATUM (Bréb.) A. Br. et Wittr.—*SS21, 22, 23,* & *25,* scarce; *SS46,* fairly common.

Only vegetative filaments present in these samples.

OEDOGONIUM VAUCHERII (Le Cl.) A. Br. et Wittr.—*SS23*, rare.

Veg. cells	23—25 μ diam.,	50—75 μ long.
Oogonia	45 μ diam.,	45—47 μ long.
Oosperes	43 μ diam.,	45 μ long.
Antheridia	20—23 μ diam.,	5—10 μ long.

OEDOGONIUM WYLIFI Tiffany—SS21, fairly common.

Veg. cells	17—25 μ diam.,	50—145 μ long.
Oogonia	60—70 μ diam.,	60— 75 μ long.
Oospores	55—60 μ diam.,	55— 63 μ long.
Suffult. cells	25—38 μ diam.,	70—113 μ long.
Antheridia	19—20 μ diam.,	10— 13 μ long.

The Chinese plants are slightly larger than the typical ones. The vegetative cell are sometimes capitellate.

In China, this species has previously been recorded from Hunan, and is also found in Szechwan. It seems to be one of the widely distributed species in southwestern China.

CLADOPHORACEAE

CLADOPHORA CALLICOMA Kuetz.—*SS1,* abundant.

The Chinese plants are densely branched, but the branches are not forming the terminal clusters. The cells of main filaments are 76—125 μ in diameter and 255—459 μ long. The cells of ramuli are either cylindrical and 25—35 μ in diameter or inflated and with a diameter up to 71 μ; both kinds of the cells are 102—280 μ long.

This species has not previously been recorded from China.

CLADOPHORA CRISPATA (Roth) Kuetz.—*SS2,* scarce.

CLADOPHORA SHENSIENSIS, sp. nov.—*SS35* (TYPE), abundant. (Fig. 2, *a*)

C. pygmaea, rigida, ad 2 cm. alta, ambitu subpyramidata; filamentis principalibus basi scatelliformi cellulae basalis et rhizoidis cellularum superiorum substrato affixis, plerumque inferne ramosissimis, superne eramosis; ramis ramulisque plerumque oppositis, interdum partim unilateralibus vel alternantibus; ramulis 1- vel 3-articulatis, plerumque simplicibus; cellulis cylindricis, interdum subtumidis, illis filamenti principalis 42—63 μ latis, 226—410 μ longis, ramulorum 32—43 μ latis, 300—560 μ longis; cellula apicali semper elongata, apice obtuse conica; membrana cellularum incrassata, indistincte lamellosa.

The branches of this species always arise from every cells of the lower portion of the main filaments and gradually become shorter upwards. End part of the main filaments is always unbranched. The branches and branchlets sometimes arise abnormally from any part of the cells. The first cross wall of the branches is sometimes laid down at some distance from the base of the branches.

This species seems to be closely allied to *C. yuennanensis* Skuja and *C. uberrima* Lambert. It differs from the first in having different dimensions, dissimilar type of its holdfast, and unbranched upper part of its main filament; and from the second

in having branches never connate at the base, much thicker ramuli, and individual plants being somewhat pyramidal in shape.

CLADOPHORA sp.—*SS11* & *23*, rare.

Only fragments are present in these samples.

RHIZOCLONIUM HIEROGLYPHICUM (Ag.) Kuetz.—*SS6* & *38: A*, scarce.

The Chinese plants are larger than the typical ones. Their dimensions are: cells 25—35 μ in diameter and 37—133 μ long.

VAUCHERIACEAE

VAUCHERIA GEMINATA (Vauch.) D. C.—*SS43*, common.

VAUCHERIA spp.—*SS14* & *31*, common.

Only sterile filaments present in these samples.

ZYGNEMATACEAE

MOUGEOTIA sp.—*SS42*, rare.

Only sterile filaments are present in this sample.

SIROGONIUM sticticum (Engl. Bot.) Kuetz.—*SS47*, common.

SPIROGYRA SUBPOLYTAENIATA Jao—*SS2*, common.

This species was described by the writer from Szechwan in 1941 (Sinensia 12: 57, fig. 2, b. 1941). This is its second discovery.

SPIROGYRA sp.—*SS4*, common.

Vegetative cells 100—110 μ in diameter, 204—280 μ long, with plane end wall; 5—6 chromatophores; conjugation scalariform; gametangia cylindrical; zygospores ellipsoid, with more or less pointed ends, not compressed, 91—102 μ in diameter, 142—178 μ long; characteristics of spore wall unknown.

Only young fruiting filaments are present in this sample. In size, this alga is quite closely allied to *S. Reinhardii* Chimelewski; in general appearance, nearest to *S. elliptica* Jao and *S. setiformis* (Roth) Kuetz.

SPIROGYRA sp.—SS*38*: *A*, scarce.

Vegetative cells 50—55 μ in diameter, 140—170 μ long, with plane end walls; 3—4 chromatophores, making 1—3 turns in the cell; conjugation scalariform; gametangia inflated, 75—80 μ in diameter; zygospores ellipsoid, 50—55 μ in diameter, 75—85 μ long; characteristics of spore wall unknown.

All fruiting filaments of this alga presented in this sample only contain the immature zygospores. According to their known characteristics, this alga seems to be closely allied to *S. reticulata* Fritsch.

SPIROGYRA sp.—*SS21*, common.

Vegetative cells 55—60 μ in diameter, 55—200 μ long, with plane end walls; 4—5 chromatophores, making 1—3 turns in the cell; conjugation scalariform; gametangia cylindrical; zygospores ellipsoid, 55—63 μ in diameter, 75—105 μ long; characteristics of spore wall unknown.

If this alga has a smooth spore wall, it is nearest to *S. hyalina* Cleve; if its mesospore is reticulate, it is allied to *S. minor* (Schm.) Transeau.

SPIROGYRA spp.—*SS1, 5, 18, 23, 24, 27,* & *28*, scarce; *SS2, 13, 16, 17, 26, 29, 34, 36, 38,* & *40*, common.

ZYGNEMA SHENSIENSE, sp. nov.—*SS13; B* (TYPE), common; *SS21*, fairly common. (Fig. 2, *b, c*)

Z. cellulis vegetativis 30—35 μ latis, (30-) 42—98 μ longis; conjugatione scalari; cellulis fructiferis plerumque abbreviatis; zygosporis aut in tubo conjugationis et in gametangia extentis aut in gametangio et in tubo conjugationis extentis, distincte compressis, aspectu facei plerumque suboviformi-obovoideis vel oviformibus, interdum subtriangularibus, aspectu vertice cylindraceo-obovoideis, 50—60 μ latis, 43—48 μ longis, 35—38 μ crassis; membrana zygosporae triplici, episporio laevi, mesosporio dense et irregulariter scrobiculato, maturitate fuscescenti, scrobiculis eiusdem zygosporae variantibus forma et magnitudine, subcircularibus vel oblongis vel irregularibus.

In size, this species is very closely allied to *Z. kiangsiense* Li. It differs from the latter in having yellowish brown and laterally compressed zygospores and pits on the mesospore being quite irregular in form and size.

ZYGNEMA spp.—SS*21, 23,* & *25,* common.

Only sterile filaments are present in these samples.

DESMIDIACEAE

CLOSTERIUM ACEROSUM Ehr.—*SS42,* rare.

Cells 535 μ long, 35 μ broad.

CLOSTERIUM VENUS Kuetz.—*SS15* & *21,* rare.

Cells 60—67 μ long, 9—10 μ broad.

COSMARIUM ABRUPTUM Lund. var. GRANULATION W. et G. S. West—*SS46,* rare.

Cells 57—58 μ long, 43 μ broad, 27 μ thick; isthmus 16 μ broad.

This variety has not previously been recorded from China.

COSMARIUM BINUM Nordst.—*SS15,* rare.

Cells 52—58 μ long, 40—42 μ broad, 28—30 μ thick; isthmus 16—17 μ bıoad.

COSMARIUM BLYTTII Willie—*SS15,* rare.

Cells 22—23 μ long, 19—20 μ broad, 12 μ thick; isthmus 16 μ broad.

The Chinese plants are a little larger than a typical form of this species. Judging from the dimensions listed above, they are nearest to *C. Bulyttii* Wille var. *novae-sylvae* W. et G. S. West, which is, however, characterized by the presence of an arc of four small granules on the lower side of the central granule.

COSMARIUM ELEGANTISSIMUM Lund. var. SIMPLICIUS W. et G. S. West—*SS22,* rare.

COSMARIUM GRANATUM Bréb.—*SS21,* rare.

Cells 34—37 μ long, 23—27 μ broad, 15 μ thick; isthmus 7—8 μ broad.

COSMARIUM LAEVE Rabenh.—*SS15, 21,* & *46,* rare.

Cells 16—20 μ long, 12—15 μ long, 8—10 μ thick; isthmus 3.5—4.5 μ broad.

COSMARIUM MONILIFORME (Turp.) Ralfs—*SS21* & *46,* rare.

Cells 27 μ long, 16 μ broad; isthmus 4.5 μ broad.

COSMARIUM PHASEOLUS Bréb. var. MINOR Boldt—*SS21,* rare. (Fig. 3, *e*)

Forma cellulis paullo latioribus. Long. 21 μ; lat. 22 μ; crass. 15 μ; lat. isthm. 6 μ.

This variety has not previously been recorded from China.

COSMARIUM POKORNYANUM (Grun.) W. et G. S. West—*SS21*, rare. (Fig. 3, *c*)

Cells 20—21 μ long, 13.5—14.5 μ broad, 8 μ thick; isthmus 4.5 μ broad, polar lobe 9 μ broad.

In China, this species has previously been recorded only from Yunnan.

COSMARIUM PORTANUM Arch.—*SS18* & *26*, rare.

Cells 33 μ long, 25 μ broad, 19 μ thick; isthmus 12 μ broad.

In China, this species has previously been recorded only from Yunnan.

COSMARIUM PUNCTULATUM Bréb.—*SS21*, rare.

Cells 34—36 μ long, 32—35 μ broad, 18—19 μ thick; isthmus 10—11 μ broad.

COSMARIUM PYGMAEUM Arch.—*SS21*, rare. (Fig. 3, *d*)

Cells 17 μ long, 19—20 μ broad, 12 μ thick without protuberance, 15 μ thick with protuberance; isthmus 4.5 μ broad.

The Chinse plant is larger than the typical form of this species. Other characteristics are typical.

COSMARIUM QUADRUM Lund.—*SS13, 18, 21*, rare.

Cells 82—85 μ long, 75—82 μ broad; isthmus 20—25 μ broad; zygospores globose, 75 μ in diameter, wall smooth.

COSMARIUM QUADRUM var. SUBLATUM (Nordst.) W. et G. S. West—*SS15*, scarce.

Cells 67—85 μ long, 73—93 μ broad, 35—40 μ thick; isthmus 23—28 μ broad; semicells subrectangular, side slightly convex and more or less upwardly diverging, apex usually slightly retuse or nearly straight; cell wall with intergrangular punctulations; granules hollow.

The Chinese plant agrees in all respects with *C. sublatum* Nordst. In 1912, W. and G. S. West suggested that this species "would be better placed as *C. Guadrum* var. *sublatum*" (Monogr. Brit. Desm. 4: 21. 1912). The writer agrees with their suggestion.

This variety has not previously been recorded from China.

COSMARIUM RECTANGULARE Grun. var. HEXAGONUM (Elfv.) W. et G. S. West—*SS46*, rare.

Cells 28—29 μ long, 23—24 μ broad, 16 μ thick; isthmus 7 μ broad.

Only a form of this variety has been recorded from China.

COSMARIUM SUBCRENATUM Hantzsch.—*SS15*, rare.

Cells 30—32 μ long, 28—29 μ broad, 17—18 μ thick; isthmus 9—10 μ broad.

COSMARIUM SUBSECURIFORME, sp. nov.—*SS21: D* (TYPE), rare. (Fig. 3, *b*)

C. mediocre, paullo latius quam longum, profunde constrictum, sinu acutangulo ampliato; semisellulis transverse ellipticis, lateribus leviter convexis divergentibus, apice late rotundato; apicibus lateralibus semicellularum truncatis et aculeis brevissimis binis ornatis, paullum infra apicem aculeo uno instructis; membrana dense punctata; a vertice visis rhomboideis, lateribus fere truncatis, apicibus denticulatis, a latere visis circularibus; pyenoidibus in utroque semicellula singulis. Long. 50—55 μ; lat. 55—63 μ; crass. 30—32; lat. isthm. 22—25 μ.

This species should be compared with *C. securiforme* Borge. It differs from the latter in having much smaller dimensions, cell wall not thickened in the central portion of the semicells, and each lateral apex of the semicells with two teeth on and a tooth below its truncate portion. It should also be compared with *C. subauriculata* W. et G. S. West, which is, however, ellipsoid in end view and with two pyrenoids in each semicell.

COSMARIUM SUBTUMIDUM Nordst.—*SS21*, rare.

Cells 33 μ long, 27 μ broad, 18 μ thick; isthmus 7 μ broad.

Typical form of this species has not previously been recorded from China.

COSMARIUM TURGIDUM Bréb.—*SS22*, rare.

Cells 165 μ long, 67 μ broad; isthmus 58 μ broad.

COSMARIUM UNDULATUM Corda f. SUBUNDULATUM Schm.—*SS21* & *46*, rare.

Cells 46—48 μ long, 43—44 μ broad, 22 μ thick; isthmus 14—14.5 μ broad.

This form has not previously been recorded from China.

DESMIDIUM APTOGONUM Bréb.—*SS13*, rare; *SS21*, scarce.

DESMIDIUM SWARTZII, Ag.—*SS21*, fairly common.

EUASTRUM BELLUM Nordst. var. MADAGASCARIENSE W. et G. S. West—*SS21*, rare. (Fig. 3, *f*)

Cells 51—52 μ long, 45—46 μ broad, 22—23 μ thick; polor lobes of semicells 18 μ broad; isthmus 10—11 μ broad.

This psecies has not previously been recorded from China.

EUASTRUM SPINULOSUM Delp. var. AFRICANUM Nordst.—*SS15*, rare.

Cells 73 μ long, 60 μ broad; isthmus 15 μ.

GONATOZYGON MONOTAENIUM De Bary—*SS21*, rare.

HYALOTHECA DISSILILNS (Sm.) Breb.—*SS21*, fairly common.

PLEUROTAENIUM ELATUM Borge f. DUPLO-MAJOR W. et G. S. West—*SS21*, rare (Fig. 3, *g*)

Cells 510—612 μ long; 55—65 μ broad at base of semicells, 50—63 μ at apex.

This form has previously been recorded only from Ceylon and India.

PLEUROTAENIUM SUBCORONULATUM (Turn.) W. et G. S. West f. MAJOR Wild.—*SS21*, fairly common.

Cells 597—750 μ long, 40—45 μ broad at base of semicells, 35—40 μ at apex.

This variety has not previously been recorded from China.

PLEUROTAENIUM TREBECULA (Ehr.) Naeg.—*SS21*, scarce.

Cells 438 μ long, 26 μ broad at base of semicells, 17 μ at apex.

PLEUROTAENIUM TRABECULA (Ehr.) Naeg. f. CLAVATA W. et G. S. West—*SS21*, rare.

Cells 325 μ long, 33 μ broad at base of semicells, 18 μ at apex. 35 μ at middle.

This form has not previously been recorded from China.

STAURASTRUM DICKIEI Ralfs—*SS46*, rare.

Cells 30 μ long, 32 μ broad; isthmus 6 μ broad; spines 4—5 μ long.

STAURASTRUM MARGARITACEUM (Ehr.) Menegh. var. ELEGANS, var. nov.—*SS21*: *E* (TYPE), scarce. (Fig. 3, *a*)

Var. semicellulis 6-radiatis, in centro cum annulo verrucarum tripapillosarum 12 et cum verruca parva tripapillosa emarginata ad basin processuum utrobique. long. 39—40 μ; lat. 46—49 μ; lat. isthm. 14—15 μ.

STAURASTRUM MARGARITACEUM (Ehr.) Menegh. var. HIRTUM Nordst.—*SS21*, rare.

Cells 38—40 μ long, 46—48 μ broad; isthmus 13 μ.

This variety has not previously been recorded from China.

STAURASTRUM ORBICULARE Ralfs var. DEPRESSUM Roy et Biss.—*SS46*, rare.

Cells 24 μ long, 23—25 μ broad; isthmus 7.5 μ broad.

STAURASTRUM PUNCTULATUM Bréb.—*SS15*, *21*, & *46*, rare.

Cells 26—32 μ long, 30—32 μ broad; isthmus 8 μ broad.

HETEROCONTAE

Ophiocytiaceae

Ophiocytium cochleare (Eich.) A. Br.—*SS21*, rare.
Ophiocytium parvulum (Perty) A. Br.—*SS21*, rare.

Tribonemataceae

Tribonema minus (Wille) Hazen—*SS29*, fairly common.

Botrydiaceae

Botrydium (?) granulatum (L.) Grev.

The writer did not find this alga in the samples he examined. The determination of this alga is only based upon a drawing made by Mr. Yen from the specimens collected from Chengku. Thus reference to this species is doubtful. As all species of this genus are unknown in China, it is worth while to add this uncertain species to the list.

EXPLANATION OF FIGURES

Fig. 1. *a, Lyngbya Bergei* Smith var. *tenuior* Jao, var. nov. X 890; *Lyngbya Cladophorae* Jao, sp. nov. X 2600; *c, Oscillatoria tenuis* Ag. var. *shensiensis* Jao, X 890; *d, Oscillatoria subamoena* Jao, X 890; *e, Anabaena shensiensis* Jao, sp. nov., X 550; *f. Anabaena Volzii* Lemm., X 550; *g, Microcystis ichthyoblabe* Kuetz., X 550; *h, Nostoc carneum* Ag., X 550; *i, Nostoc spongiaeforme* Ag. var. *regulare* Jao, var. nov., X 890; *i, Nostoc shensiense* Jao, sp. nov, X 890.

Fig. 2. *a, Cladophora shensiensis* Jao: base of a plant, showing holdfast of the basal cell, rhizoidal downgrowths, and types of branching, X 95. *b* and *c, Zygnema shensiense* Jao, sp. nov.; *b,* part of the fruiting filament, showing different forms of the zygospores in front view; *c,* zygospore in vertical view, X 315. *d, Auloseira confluens* Jao, sp. nov., X 550. *e—g, Bulbochaete nitida* Jao, sp. nov.; *e* and *f,* habit of two plants, showing positions of the oogonia and antheridia, X 360; *f,* lower part of a mature oospore, showing structure of the spore wall, X 890. *h, Oedogonium oblongum* Wittr. var. *polymorphum* Jao, X 360, *i* and *j, Oedogonium intermedium* Wittr. var. *breviarticulatum* Jao, X 360, *k, Oedogonium fragile* Wittr. var. *subdepressum* Jao, X 360.

Fig. 3. *a, Staurastrum margaritaceum* (Ehr.) Menegh. var. *elegans* Jao, X 890; *b, Cosmarium subsecuriforme* Jao, sp. nov., X 550; *c, Cosmarium Pokornyanum* (Grun.) W. et G. S. West, X 890; *d, Cosmarium pygmaeum* Arch, X 890; *e, Cosmarium Phaseolus* Bréb. f. *minor* Boldt., X 890; *f, Euastrum bellum* Nordst. var. *madagarscariense* W. et G. S. West, X 890; *g, Pleurotaenium elatum* Borge f. *duplo-major* W. et G. S. West, X 315; *h, Coelastrum shensiense* Jao, sp. nov., X 890; *i, Coelastrum proboscideum* Bohlin, X 890; *j, Scenedesmus shensiensis* Jao, sp. nov., X 890; *k, Scenedesmus polycostatus* Jao, sp. nov., X 890.

Fig. 1

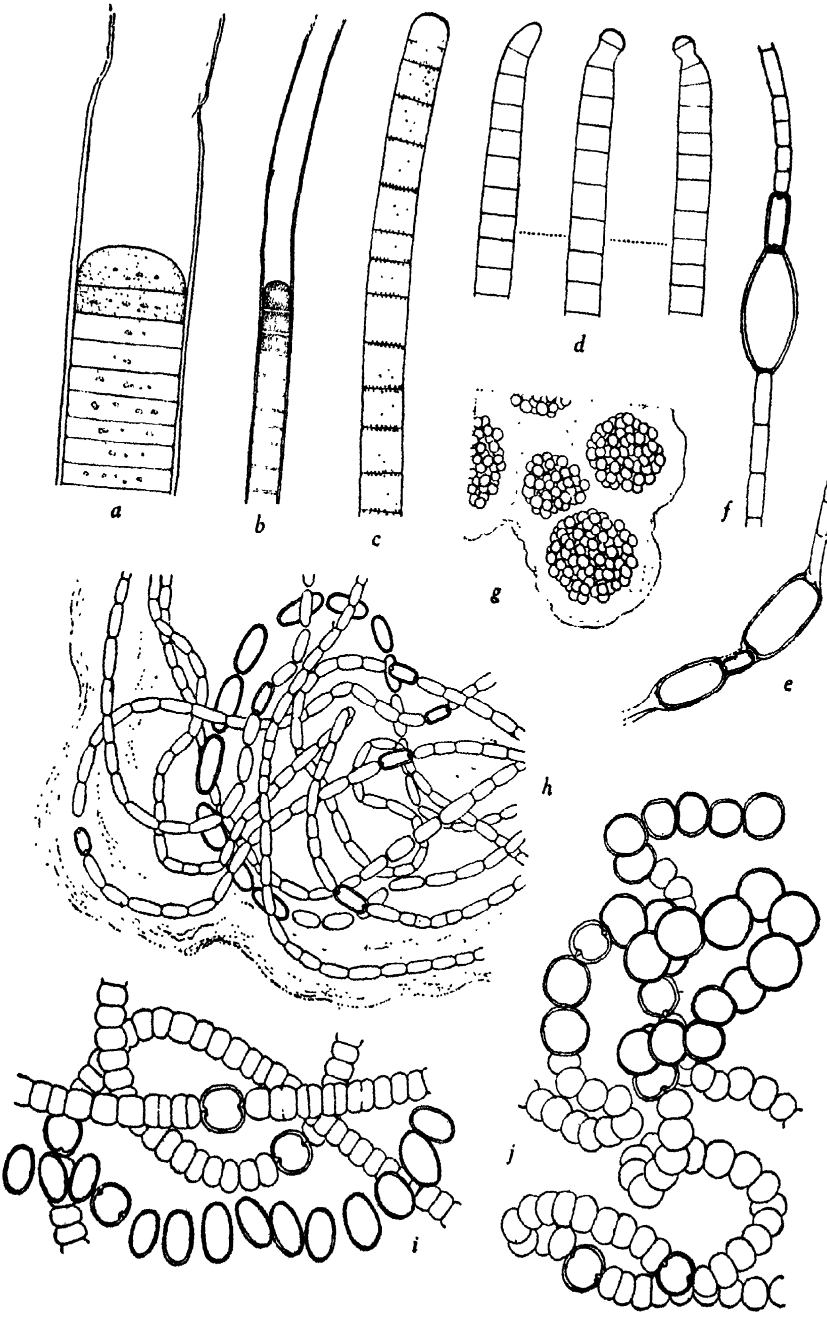


Fig. 2

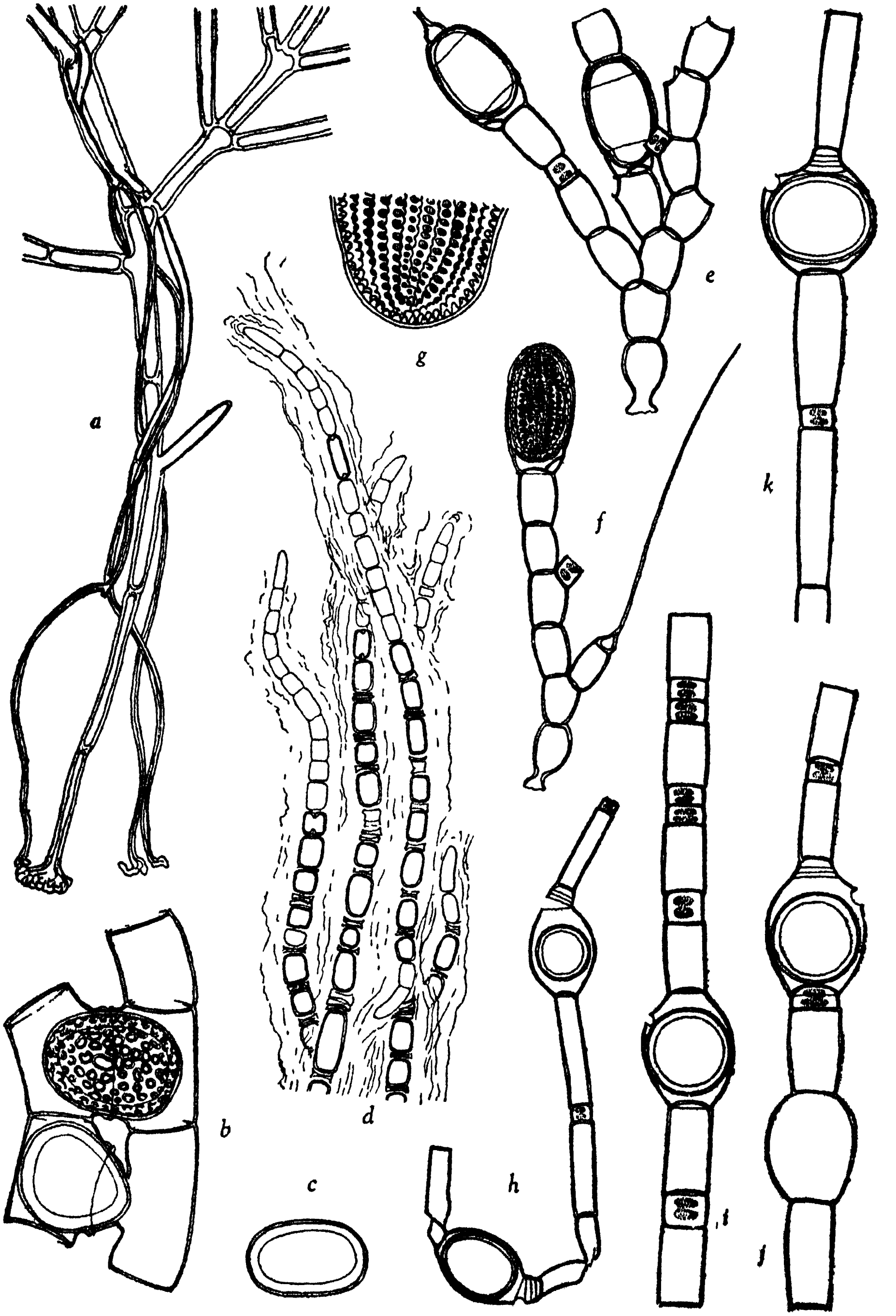
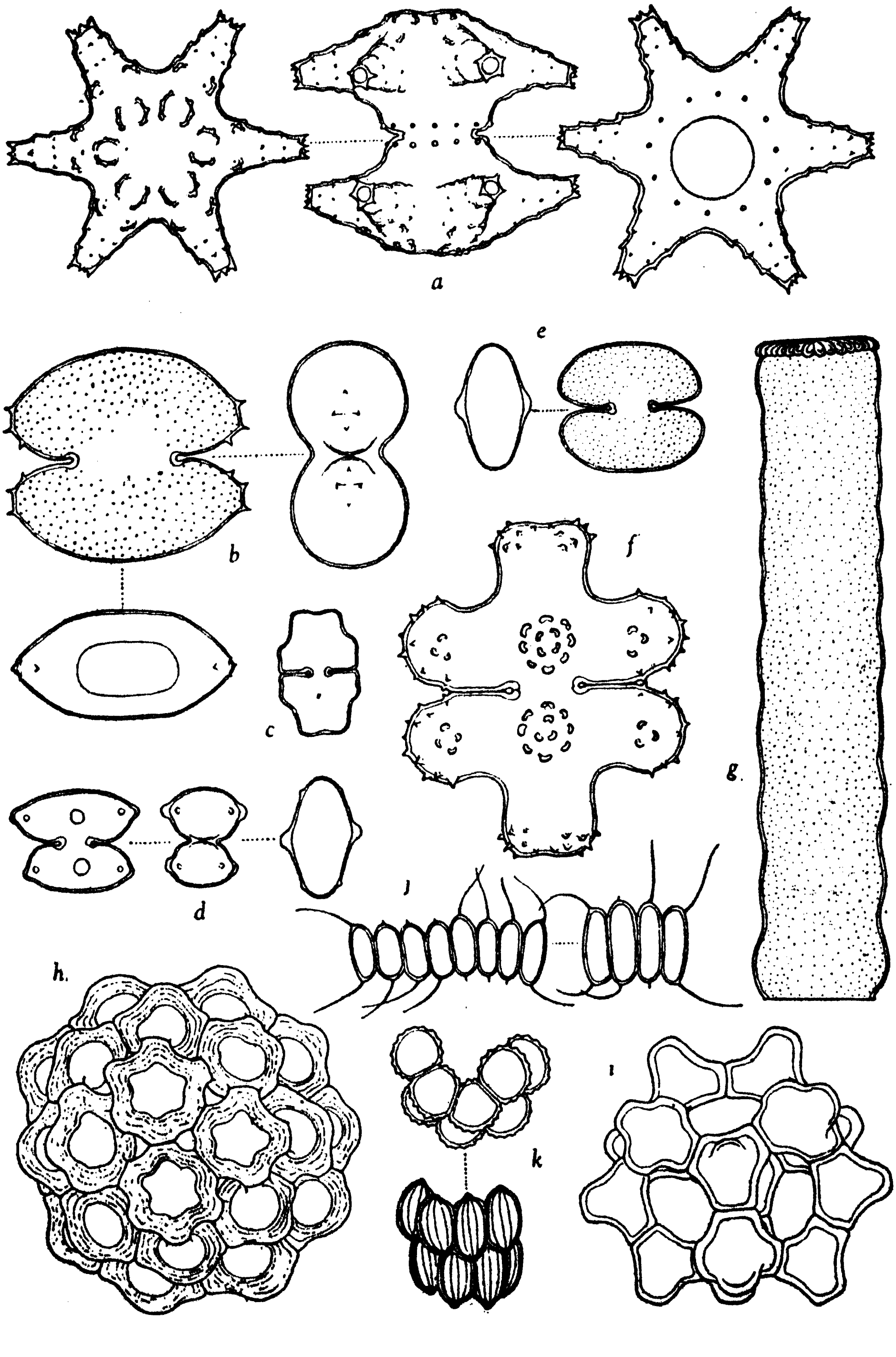


Fig. 3



FOREST GEOGRAPHY OF THE EAST-TIBETAN PLATEAU

S. C. Teng

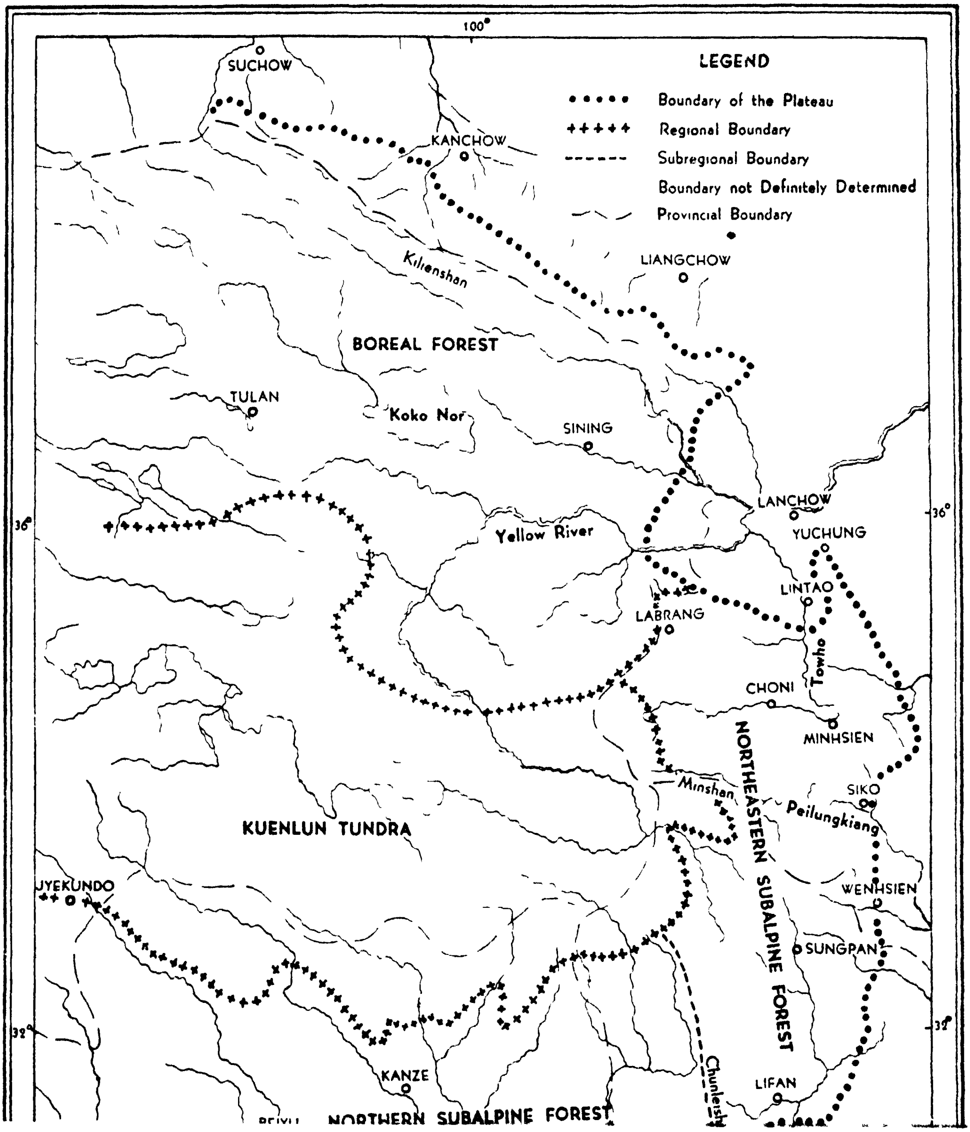
The East-Tibetan Plateau has originally been referred to the eastern part of Tibet called Chuanpien, a mountainous highland projecting southward from the Tibetan Plateau Proper and lying athwart the eastern end of the Himalaya. Physiographically, the plateau extends as far north as Kilienshan and as far south as northwestern Yunnan. Its boundaries are well defined in the north and the east by sudden rise in elevation. In the south, it merges with the Yun-Kwei Highland. The western boundary is only vaguely marked by the disappearance of forest in deep river canyons and the beginning of continuous alpine meadow on more rolling country of the Tibetan Plateau Proper. Thus the East-Tibetan Plateau embraces roughly the area east of the Tsaidam Basin and Jyekundo of Chinghai and Chamdo of Sikang. It includes E. Chinghai, E. Sikang, SW. Kansu, NW. Szechuan and NW. Yunnan. Cressey (1) names this physiographic unit "Tibetan Borderland" with boundaries approximately the same as delimited by the writer in the accompanying map.

In general, north of the Kuenlun axis, the plateau is less rugged and lower in elevation. The altitude ranges from 6,500 feet at the foot of the plateau to 19,600 feet at the highest peak. South of the Kuenlun Range, the general elevation is over 10,000 feet with the highest peaks, such as Minya Gonka, rising to an altitude of about 25,000 feet. The plateau here is cut by several rivers into numerous deep parallel gorges. These run in general from NNW to SSE, while the intervening country appears as a series of lofty mountains trending in the same direction. The most prominent north-south range is the Chunleishan, known to foreign travellers as Yunling Mts. or Szechuan Alps, which appears to merge with the Himalaya and Kuenlun axes at either end. On the other hand, some travellers, as Little (3) and others, have observed a west to east trend which runs from Batang to Tachienlu with snow clad peaks rising to heights of over 20,000 feet. This they call the Tashuehshan or the "Great Snow Range".

The climate of the plateau is as a whole very rigorous. There is almost no real summer. The temperatures are low. They vary greatly from the bottoms of the valleys to the summits of peaks, and decrease in general from south to north. Due to the increasing distance from the ocean, there is likewise a gradual northward decrease in precipitation.

This plateau is the most heavily wooded region in China except Manchuria and is also one of great phytogeographic complexity. The forest flora in this vast area shows several distinct units. The main axis of Kuenlun traversing the middle of the plateau is alpine tundra with numerous snow capped peaks. On the north of it, owing to dry climate, exists the Boreal Forest. South of the Kuenlun Range and on its eastern spur, the Minshan, is the Subalpine Forest. The latter may be divided into four subregions according to differences in the component species of the forest communities.

FOREST REGIONS OF EAST-TIBETAN PLATEAU



BOREAL FOREST

This region north of the Kuenlun axis is bounded by the steppe country on the north and the west. It meets the Loess Highland in the east and the Subalpine Forest in the southeast. It represents a transitional zone from the Subalpine Forest to the steppe. The topography and drainage are decidedly irregular, and the precipitation varies from about 10 to 20 inches per annum. On these accounts, the vegetation in some places shows a higher degree of xerophytism than in others.

In this region there occurs but one single climax dominant, *Picea asperata* Mast., which runs from an altitude of 6,500 feet up the northerly slopes to timberline at 11,500 feet. The trees here are short, tapered and of small size as compared with those in the Subalpine Forest. On southerly exposures and drier locations, as in the hills bordering the Tsaidam Basin, junipers occur as preclimax dominants. Alternation is strikingly evident. Seral communities are mostly *Populus Davidiana* Dode and scrubs consisting of *Potentilla, Caragana,* etc. *Betula* and *Rhododendron* are but rarely found, while *Arundinaria* which is abundant in the Subalpine Forest, is completely lacking. Along stream banks, *Populus cathayana* Rehd., *Salix, Myricaria* and *Hippophae* occur as seral stages. On the foot-hills, *Pinus tabulaeformis* Carr. and *Ulmus pumila* L. are found.

Altogether the forest of this region may be characterized by relatively small number of tree species, small size and slow growth of trees due to severe climate, dominance of *Picea asperata,* prevalence of junipers as subclimax species, and the broken nature of the forest due to confinement of the principal forest growth to northerly aspects.

The Boreal Forest has its outpost at Alashan in Ningsia Province where the forest, surrounded by the steppe and desert country, has general characters similar to those described above.

SUBALPINE FOREST

South of the Kuenlun Range and east of its great alpine tundra, there extends an extensive forest region with species of spruce and fir dominating. The occurrence of these species is characteristic of the Subalpine Forest. *Rhododendron* and *Arundinaria* which are practically absent in the Boreal Forest, are frequently found as undergrowth throughout this vast formation. According to differences in the species constituting the climax dominants, four distinct subregions may be recognized: The Northeastern, the Northern, the Southern, and the Southeastern Subalpine Forest.

Northeastern Subalpine Forest
(*Abies Faxoniana - Picea purpurea* Association)

This subregion lies east of the Kuenlun Tundra and stretches from SW Kansu southward across Minshan and the northwestern corner of Szechuan Province to the Szechuan-Sikang border. It is characterized by the occurrence of *Abies Faxoniana* Rehd. et Wils. and *Picea purpurea* Mast. as climax species, and of *Picea Neoveitchii* Mast. which dominates the foot-hills. Birch-aspen associes is characteristic of this region. This includes *Betula albo-sinensis* Burk. and its variety *septentrionalis* Schneid., *Betula mandshurica* var. *szechuanica* (Schneid.) Rehd., and *Populus Davidiana* Dode. *Pinus tabulaeformis* Carr., *P. Armandi* Franch. and *Populus cathayana* Rehd. are also common.

A gradual transition from the Boreal Forest to the remaining parts of the Subalpine Forest is shown in this subregion. *Picea asperata* Mast. which forms the climax dominant of the Boreal Forest and absent from the other Subalpine Forests is a subclimax species here. In the northern part, the Towho Watershed, the juniper preclimax is distinctly present on southerly aspects as in the Boreal Forest, showing conspicuous alternation with the spruce and fir climax. While *Larix Potaninii* Batal. and *Tsuga chinensis* (Franch.) Pritz. are frequent associates in the Subalpine Forest, the former becomes rare in the Towho Watershed and the latter does not grow. Furthermore, the topography in Towho Watershed is less steep and rugged than in other parts of the Subalpine Forest, and the precipitation is lower, varying from 20 to 25 inches per annum. The timberline here occurs at the same altitude as in the Boreal Forest.

Passing over the Towho-Peilung Divide, one immediately finds that the southern part of this subregion manifests a closer relationship to the remaining Subalpine Forests than to the Boreal Forest. Here in the Peilung Valley the topography at once becomes very rugged; *Tsuga chinensis* (Franch.) Pritz., *Taxus chinensis* (Pilg.) Rehd. and *Abies chensiensis* Van Tiegh. all come into the forest composition; and *Larix Potaninii* Batal. commences to be found in greater frequency. Further south in Peishuikiang Watershed, *Picea complanata* Mast. which is really a form of *Picea brachytyla* (Franch.) Pritz. of the Southeastern Subalpine Forest, begins to appear.

NORTHERN SUBALPINE FOREST
(*Abies squamata - Picea Balfouriana* Association)

The territory south of the Kuenlun Range and north of Tashuehshan belongs to this subregion. It is demarcated in the east by Chunleishan and stretches from Tachienlu eastward to Chamdo. The general elevation here is over 10,000 feet and the climate is relatively dry and cold as compared with the subregions further south. Records taken at Tachienlu show that the mean temperature is about 11° C. and the annual precipitation amounts approximately to 25 inches.

The dominant climax species here are *Abies squamata* Mast. and *Picea Balfouriana* Rehd. et Wils. The former grows up to the timberline which occurs at a higher altitude, 14,200 feet, than in the Boreal Forest. Aside from the difference in the dominant species of the climax community, the forest composition of this subregion differs from the southern part of the previous subregion in the increased importance of *Larix Potaninii*, in the entry of *Tsuga yunnanensis* (Franch.) Mast., *Picea retroflexa* Mast., *Quercus semicarpifolia* Smith, etc., and in the disappearance of *Picea asperata, P. Neoveitchii,* and *Populus Davidiana* which are prominent elements in the Northeastern Subalpine Forest.

In this subregion *Pinus tabulaeformis* is displaced by its variety *P. t. densata* (Mast.) Rehd., *Picea retroflexa* seems to substitute for *P. asperata,* and *Quercus semicarpifolia* appears to take the function of *Populus Davidiana* in the forest succession. *Q. semicarpifolia* commonly assumes a scrub form and oftentimes constitutes subseral communities. The scrub-oak community generally arises from the clear cutting of the coniferous forest, often followed by fire, in which the oak existed only as scattered individuals. Owing to its sprouting ability, it is able to maintain and increase itself under adverse conditions.

As compared with the Boreal Forest, alternation is less striking in this subregion although southerly slopes are mostly occupied by *Juniperus* spp., *Quercus semicarpifolia* and *Pinus tabulaeformis* var. *densata*. This may be explained to a large extent by the fact that the river gorges generally run from north to south with slopes mostly facing east and west.

The forest flora of the Northern Subalpine Forest is also characterized by a decrease in complexity from southeast to the north and the west, due to higher precipitation and lower elevation in the southeast. In consequence, species of relatively low altitudinal distribution, such as *Tsuga chinensis, T. yunnanensis, Abies chensiensis, Picea retroflexa* and *Pinus tabulaeformis* var. *densata*, gradually drop out as the general elevation increases toward the north and the west. Meanwhile, forest in the northern and the western part of this subregion appears only in the gorges. In the extreme west, at the headwaters of Mekong near Jyekundo and Chamdo, *Abies squamata* lags behind *Picea Balfouriana* in their westward march. The latter then forms pure stands owing to its less exacting moisture requirement.

Southern Subalpine Forest
(*Abies Georgei - Picea likiangensis* Association)

The part of the plateau south of Tashuehshan falls under this subregion. It merges with the Yun-Kwei Highland in the south and is separated from the Southeastern Subalpine Forest by the Yalung-Tatu Divide. Its western boundary probably follows a line running from the southern portion of the Kinsha-Mekong Divide northwestward along the Mekong-Salween Divide. A definite determination of this boundary has to wait till more knowledge concerning that part of the country is available.

The general elevation of the plateau in this subregion varies from about 8,000 to 17,000 feet above sea level. In the valleys within its southern border, the mean temperature is probably somewhere around 14° C. and the annual precipitation about 35 inches. A general decrease in elevation and increase in temperature and precipitation are evident in comparison with the Northern Subalpine Forest. The timberline, however, remains at the same altitude as in the previous subregion.

The principal species constituting the forest flora in the Southern Subalpine Forest are *Picea likiangensis* (Franch.) Pritz., *Abies Georgei* Orr, *Larix Potaninii* Batal., *Pinus yunnanensis* Franch., *P. Armandi* Franch., *Abies chensiensis* Van Tiegh., *Tsuga chinensis* (Franch.) Pritz., *T. yunnanensis* (Franch.) Mast., *Quercus semicarpifolia* Smith and *Betula albo-sinensis* Burk. The first two are the dominant climax species, while *L. Potaninii* and *P. yunnanensis* frequently form subclimax communities on southerly slopes. *P. tabulaeformis* var. *densata*, a member of the Northern Subalpine Forest, is here replaced by *P. yunnanensis*. The latter is especially abundant near the southern border of this subregion where the Subalpine Forest merges with the Montane Forest in the Yun-Kwei Highland. *Abies Delavayi* Franch. may occur at the southwestern border. It is very likely a dominant species of another association in a narrow stretch of territory southwest of this subregion. North of the Yunnan border, the Salween Valley, being enclosed on both sides by high mountains, is known to be a hot and dry region with annual precipitation probably under 10 inches. The woody vegetation there consists of drought-resistant shrubs and junipers.

SOUTHEASTERN SUBALPINE FOREST
(*Abies Faberi* - *Picea brachytyla* Association)

This subregion lies east of Tachienlu and extends along the southeastern border of Sikang Province. It is the southeastern fringe of the plateau with a general elevation lower than in the last two subregions. Both temperature and precipitation are higher than in any other part of the plateau. The former averages 15° C. and the latter probably exceeds 40 inches per annum.

From an altitude of 8,000 feet up, the spruce-fir forest occurs, with *Abies Faberi* (Mast.) Craib. and *Picea brachytyla* (Franch.) Pritz. dominating. *Tsuga chinensis* and *T. yunnanensis,* particularly the latter, appear in greater abundance than in the previous subregions. They are understory species in the climax forest. *Larix Potaninii* is here rarely met with and pines are not found at all, but *Betula albo-sinensis* is of common occurrence as seral species. The phenomenon of alternation is least exhibited in this subregion, since *Picea brachytyla* grows here also on south-facing slopes in mixture with junipers.

At the foot-hills this forest association touches a zone of broad-leaved forest of mixed evergreen and deciduous trees. This is apparently due to the mild and humid climate of the subregion and does not happen in other parts of the plateau. The trees making up the broad-leaved forest include species of *Castanopsis, Schima, Lithocarpus, Lindera, Quercus, Populus, Betula, Acer,* etc. Their ecological characters have not been studied by the writer.

DISCUSSION

The above analysis of the forest flora of the East-Tibetan Plateau is necessarily a preliminary one. It is based primarily on the observations of the writer during several field trips traversing the plateau. Forest surveys made by Ku and Cheo (2) and others have also yielded useful data many of which tend to confirm or to supplement the writer's observations.

Ward (4) has written several articles on the geography and botany of Tibet as a physiographic unit, one of which is cited here. He deals with the whole Tibet and divides it into four geographic and botanical divisions: (A) The Great Plateau which embraces the Great Plateau Proper and Tsaidam and is characterized by internal drainage and the lack of woody vegetation; (B) the Outer Plateau which slopes from the rim of the Great Plateau toward southeast, includes Gravel-lands in the south and west and Grasslands in the north and east, and is characterized by outward flowing streams in wide shallow east-west valleys and by alpine flora with trees—chiefly junipers—confined to water courses; (C) the River Gorge Country which is divisible into the Upper Gorge Country and its outlying part, the Lower Gorge Country, and is characterized by rich forest flora and by streams cutting deep north-south gorges through lofty containing walls; and (D) the Chinese Tibet which is not discussed but is merely denoted as the eastward extension of the River Gorge Country. Ward regards all these four divisions as belonging to one floral region which he terms the "Sino-Himalayan Region."

The East-Tibetan Plateau treated in the present paper applies only to the eastern end of Ward's physiographic Tibet. The territory embracing our Boreal Forest and the Towho Watershed of the Northeastern Subalpine Forest is considered by Ward as

a part of the Grassland of the Outer Plateau, while the remaining portions of our Subalpine Forest lie mainly in the Chinese Tibet as designated by Ward and also in the northeastern end of the Upper Gorge Country. Obviously, the writer's treatment of the East-Tibetan Plateau deviates from Ward's scheme of division into regions.

Much work remains to be done especially at the southwestern corner of the plateau west of Kinshakiang. It was originally planned to conduct more investigations to bring out all the necessary details before attempting to make a definite statement. As the outlook for the continuation of this study is not at all bright, a provisional conclusion is therefore drawn.

The purpose of this paper is to present a general view of the forest flora of the plateau, giving the facts but without attempting to explain the whys. The writer hopes that the information embodied herein will be useful to foresters and plant geographers and that the evidence furnished by the vegetation will throw some light upon the complex and incompletely known geological structure of this vast territory.

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NOTES ON SOME CHINESE HETEROCONTAE AND CHRYSOPHYCEAE. I

CHIN-CHIH JAO

Our knowledge on the Chinese Heterocontae and Chrysophyceae is very scanty. Only a few species belonging to some common genera have been recorded previously. During the writer's investigation on the freshwater algae collected in different localities of China, some new facts concerning the morphology, life-histories and geographical distribution of Heterocontae and Chrysophyceae have come to light. It is intended to report these new facts in a series of notes.

HETEROCONTAE

MISCHOCOCCUS CONFERVICOLA Naeg.

Colonies dendroid, attached to coarse filamentous algae by an emptied basal cell, up to 100 μ tall; cells globose, 2 or 4 arranged into a single vertical row at the ends of the dichotomously branched gelatinous stalks, mostly 4.5—5.5, sometimes 3.5 or 6.5 μ in diameter; chromatophores 2, parietal, laminate, yellowish green, opposite to each other, each occupying nearly one half of the cell; cell wall thin, that of the emptied cells always persisting in the forked portions of the gelatinous stalks.

Epiphytic on *Tribonema minus* (Wille) Hazen in a pool behind the Chungshan Hospital, Shanghai, March, 1947 and 1948. Fairly common.

The monotypic family Mischococcaceae contains only one rare species, *M. confervicola,* which has been recorded only from a few localities in Europe and North America.

CHLOROTHECIUM PIROTTAE Borzi

Cells ovate or subobovoid, shortly stalked, attached to coarse filamentous algae by a widely expanded, deep-brown and disc-shaped holdfast; 14—16 μ in diameter, 24—32 μ long; chromatophores yellowish green, 4—6 in each cell, usually more or less diffused with age; aplanospores 4—64 formed in each vegetative cell, 6—7 μ in diameter at maturity, with a fairly thick wall, always embedded in a gelatinous matrix which is connected with the apical opening of the spore mother-cell.

Associated with the preceding species. Rather rare.

Chlorothecium is also a monotypic genus. *C. Pirottae* has previously been recorded only from a few localities in Europe, and is a very rare alga.

As described by former algologists, this alga reproduces by 4—16 aplanospores with a bivalved membrane, which are liberated by the separation of the two halves of the wall. In the present material, the aplanospores formed in a single vegetative cell are usually 16, 32, or, sometimes, 64 in number. The aplanospores are liberated from a very wide apical opening of their mother cell. This opening is the result of the increase in size of the aplanospores. The writer examined many fruiting individuals of this alga in different developmental stages, but did not find the separation of the cell wall into two halves to liberate the spores.

CHRYSOPHYCEAE

HYDRURUS FOETIDUS (Vill.) Kirchn.

Nanurus flaccidus Skuja, *in* Handel-Mazzetti, Symbolae Siniceae, I, Algae, 45, fig. 5. 1937.

This species has been reported from the Sikang province by the writer in 1940 (Sinensia 11: 534. 1940). At the same time he noted that the young plants of this species are unbranched or with a few simple branches, and agree in structure and general appearance with *Nanurus flaccidus* (loc. cit.), a new genus and species described by Skuja from Yunnan. Recently, the writer has reexamined all young plants in the Sikang sample and found that *Nanurus flaccidus* is certainly a young plant of *Hydrurus foetidus.* For this reason, *Nanurus* should be considered as a synonym of *Hydrurus,* and *N. flaccidus* a synonym of *H. foetidus.*

PHAEOTHAMNION CONFERVICOLUM Lagerh.

Thallus up to 100 μ tall, attached to other filamentous algae by a thick-walled, hemispherical basal cell; branches mostly opposite or sometimes partly alternate, issuing either from the cells next to the basal cell or from all cells of the thallus including its basal cell; cells mostly cylindrical-obovoid, with more or less convex sides, 5.5—9.5 μ in diameter, 9—29 μ long; basal cell 8—11 μ in diameter, 5—7 μ long, with a wall up to 2 μ thick and more or less distinctly lamellose; chromatophores mostly single or rarely two in each cell, golden-brown, parietal, laminate, with an irregular margin, occupying more than one half of the cell.

Growing on *Cladophora* in a pool near Pehpei, Szechwan, March 16, 1945. Rare.

This species seems to be widely distributed in the world, but is also a rather rare alga. It has not previously been recorded from China.

SEED-BORNE DISEASES OF SOYBEAN

Sih-tsing Liu

Seed-borne diseases are common and important in soybean. The death of many diseased seedlings at an early stage often escapes attention, but sometimes causes poor stand and produces the primary inoculum from which later epiphytotic may result.

In the present work, materials were collected from Nanking, Peiping, Sian and Chengtu during the years of 1945-1947 for laboratory studies, while field observations were confined to Chengtu and along the Nanking-Shanghai Railway line. Seeds of both types of soybeans, namely, the Yellow-seed and the Green-seed, that show discolorations or deformities, suggesting the presence of pathogen, were collected.

In isolation work these seeds were surface-sterilized by first immersing in ninety-five per cent alcohol for about 30 seconds and then soaking for two minutes in 1:1000 mercuric chloride solution. They were washed in sterile water for five minutes, planted on potato-dextrose agar in the Petri dishes, and incubated at 25° C. for various periods.

Inoculation experiments were carried out with seedlings, pods, and seeds. In seedling inoculation 1200 plants, that were about five to six inches in height and grown in pots, were divided into 24 lots. Each lot was inoculated with a conidial suspension or bits of mycelium of one organism and one lot was retained as control. Half of the plants in each lot were wounded on the cotyledons, the hypocotyls, and the leaves. The plants were placed in a moist chamber at 25° C. for 48 hours, and then removed into greenhouse. For about two weeks symptoms caused by some organisms appeared on the cotyledons, the hypocotyls, and the leaves, while those caused by other weak parasites occurred only on the cotyledons.

Inoculations with pods were carried out by first sterilizing healthy pods containing seeds in 1:1000 solution of mercuric chloride for 2 to 3 minutes and washed in sterile water for 5 minutes. Half of each lot of thirty pods were wounded. Twenty-three lots were inoculated, by soaking in spore suspensions or by insertion of a bit of mycelium of the organisms. One lot served as control. They were placed on a moist paper in Petri dishes and incubated at 25° C. for two weeks. Neither in the control nor in the inoculated pods did the diseases appear. The experiments were repeated, but negative results were obtained every time.

In another experiment, seeds were removed aseptically from healthy pods and placed on a sterile moist paper in Petri dishes. Each lot contained fifty seeds and half of them were wounded. There were fourteen lots. They were inoculated with spore suspensions or with mycelium of the organisms which had been proved to be pathogenic on the seedlings, and incubated at 25° C. At the end of two weeks, all the seeds showed discolorations while the control did not.

When the inoculation tests were repeated with similar results the organism was considered pathogenic and identified. The symptoms they produced were recorded. These diseases are described in the order of decreasing importance.

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POD AND STEM BLIGHT

The pod and stem blight causes a serious damage to the soybean in Chengtu and Nanking, especially under moist conditions. Stems, pods, seeds and sometimes petioles are attacked. Leaf-infections are occasional. The disease first appears on the lower stem at the junction of a branch or petiole or it attacks the branches that are injured by insects, wind, or the weight of pods. The lesions on stems are English red (all colors refer to Ridgway's Color standards and nomenclature), and when the fungus girdles the stem, the latter gradually dies and the development of the young pods is prevented. Pycnidia of the causal organism, *Diaporthe phaseolorum* var. *sojae* Wehmeyer, develop on the surface of such areas as the stems die, and sometimes it is accompanied by the fruiting bodies of other organisms, especially that of *Glomerella glycines*. The symptom on stems is similar to the anthracnose, but the fruiting bodies of the pod and stem blight fungus are usually arranged in a linear order, whereas those of the anthracnose are scattered over the surface of the affected stems. This characteristic will assist in distinguishing these two diseases.

The heaviest loss occurs when the pods are attacked in the rainy season. The young pods drop off when attacked, while the old ones wither though remaining attached. Black fruiting bodies of the causal fungus are often present on the light buff, antimony yellow, or zinc orange surface of these infected pods.

As the pathogen penetrates deeper into the pod, the developing seeds are invaded. The lesions are Saccardo's umber in color and the seeds frequently shrivel. Sometimes this disease is the chief cause of seed infection. In 1947, 420 diseased seeds of the early Yellow-seed variety were collected from the market of Tanyang, Kiangsu. Except 33 discolored seeds, all produced fungous and bacterial colonies on potato-dextrose agar, with the pod and stem blight fungus showing the highest frequency, yielding 149 isolates (35.48%). *Glomerella glycines* constitutes 16.90% of the total number of isolates, *Cercospora kikuchii* 12.62%, *Fusarium* spp. 7.86%, *Penicillium* spp. 7.14%, *Aspergillus* spp. 5.95%, Bacteria 3.35%, *Choanophora* sp. 1.67%, *Alternaria atrans* 0.95%, and *Phyllosticta sojaecola* 0.24%.

When the seedlings are artificially inoculated, only the cotyledons are infected. The lesion starts from a wound as a small, sorghum brown spot, without much enlargement. Lehman (9) who first found this disease in North Carolina observed that this fungus caused the death of soybean seedlings by growing from seed coat on to the hypocotyl and causing its decay. Such occurrence has never been observed by the writer.

Lehman (9) was the first to find the conidial stage of the causal fungus in 1922 and named it *Phomopsis sojae*. In the next year he (10) obtained its perfect stage from culture and named it *Diaporthe sojae* as a species distinct from *Diaporthe phaseolorum* (Cke. and Ell.) Sacc. Wehmeyer (23), considering the differences between the two species not sufficient to warrant the separation of species, treated *D. sojae* as a variety of *D. phaseolorum*. The writer is in agreement with Wehmeyer. According to his experience the variety differs from the type species chiefly in pathogenicity. Although the sizes of pycnidia and pycnidospores of these fungi are slightly different, the difference is within the range of variation.

In cultures, the rate of growth is moderate. The whitish mycelium develops well on the agar with short aerial hyphae, producing abundant pycnidia along the wall of the test tubes but no perithecia. The pycnidia are subglobose, simple or in groups, ranging from 90 to 320 μ in diameter; pycnidiospores are hyaline, continuous, elliptic, with 1-2 oil globules, 6.1-10.1 × 2.4-3.5 μ; stylospores uncommon, filiform, slightly hooked at one end, non-septate, hyaline, 20.0-26.5 × 1.4-2.1 μ.

Purple speck of seed

The occurrence of the purple speck on the seed is world wide and has long been noticed by many growers and investigators in Japan and China. The pathogen also infects leaves, stems, pods, but much less frequently.

On seed it is characterized by the appearance of pansy purple, dull dark purple, then liver brown, or almost Prout's brown, more or less irregular patches or stripes without distinct margin. The discoloration is frequently accompanied by rifts. The size of lesions varies from mere specks to the entire seed coat. The depth of the discoloration is limited to the seed coat, rarely reaching the surface of the cotyledon. On the stem, the lesion develops occasionally. They are blackish brown (1) and slightly sunken. On the pod, this disease usually occurs in the later part of development, but the lesions are not so marked as those on seeds. In leaf infections, the young spots are small and hazel in color. As the disease advances, the centers of the spots become carob brown. The spots enlarge and become irregular in shape, or they are more or less angular, being limited by veins and veinlets. Some of the adjacent spots may coalesce to form more extended necrotic areas, usually intersected by the hazel colored tissues between lesions.

This disease was studied by Suzuki (21) in 1921 and he considered the climatic conditions as the chief cause. Mechanical injuries, produced by the stress resulted from the unequal growth rate between pod and seed, developed into the lesion. Kikuchi (1922) studied the causal agent and suggested that the pathogen might be a parasitic fungus belonging to the genus *Cercospora*. Kung (8) proved the pathogenicity of a parasitic fungus causing this disease, but he did not identify it. The Shigaken Agricultural Experiment Station (20) reported that this disease might be caused by a *Fusarium*. It was finally demonstrated by Matsumoto and Tomoyasu that a *Cercospora* which they named *C. kikuchii* in 1925 (16) is the causal agent with its pathogenicity proved by inoculation experiments.

When naturally infected seeds were germinated on moist paper in Petri dishes, the white velvety mycelium developed on the affected part and conidiophores and conidia were formed. Conidiophores are well developed, straight or somewhat curved, 2-7-septate. They are yellow ochre when young, and turn to mars brown with age, and ochraceous tawny or almost hyaline near the apex. The measurement of 50 conidiophores ranges 165-559 μ in length. The conidia are hyaline, vermiform or filiform, straight or curved, 0-16-septate. They are easily detached from the conidiophores. The conidia measured 67.0-129.6 × 3.6-5.1 μ.

Since the conidia germinate readily at a moderate temperature, they are very difficult to obtain from the pure culture. According to Matsumoto (15) the optimum temperature for the conidial formation was 15-20° C.. The writer observed the conidial

formation on the affected part of the diseased seeds placed on moist paper or on potato-dextrose agar in Petri dishes at 25° C. for 2-4 days. Sometimes they were also observed on the infected cotyledons.

Pure cultures of the fungus were made and its growth rate and degree of sporulation tested on potato-dextrose agar at 25° C. In most cases, the rate of growth is very slow. Conidia begin to appear about 2-4 days after the seeds are placed on the medium, but they soon germinate, and can no longer be found after seven days. The hyphae, at first, form a white velvety mass which later becomes maroon in the center and carnelian red along the margin, and finally forms a pale smoke gray mat at the surface of the medium. The maroon coloration gradually diffuses throughout the agar medium. An old culture is fuscous in color, and without any spore.

Cercospora leaf spot

The disease appears on the foliage of soybean as small liver brown, circular spots which later enlarge and turn kaiser brown. The spots, 4-8 mm. in diameter, may be few in number or they may be so numerous as to coalesce and form large irregular dead areas often surrounded by apricot orange, irregular margins. The infections occur mostly on the lower leaves, sometimes on the pods, and on the seeds, rarely on the stems. On the pods, it causes the loss of vitality; in case of severe attacks seeds fail to form. The pathogen usually attacks the immature pods and characteristically form black velvety, irregular patches, but not the mature ones. It may penetrate into the pod and spot the seed. On seeds the spots are fuscous, or fuscous black, irregular, and are confined to the seed coat.

The disease occurs commonly on cowpea plants in China with similar symptoms. The spots are visible on both sides of the leaves, circular or subcircular, kaiser brown, with concentric hessian brown rings. On the stems the lesions are hessian brown. In China and America the disease causes more damage on the cowpea than on the soybean.

The disease is caused by *Cercospora vignicola* Kawamura. It was first described as *Cercospora vignicola* from specimens on cowpea (*Vigna sinensis* (L.) Endl.) by Kawamura (7) in 1931. In 1945 Olive and others (19) described a fungus from cowpea and soybean as *Helminthosporium vignae*. From their descriptions these two organisms seem to be the same. The differences in size and septation of the conidia and conidiophores are small, well within the range of variation.

The writer isolated these fungi both from leaves of cowpea and from diseased seeds of soybean. Pure cultures were made from spores. No difference in the cultural characters between them had been observed. The growth rates are moderate. The hyphae first form a white flocculent colony, which later becomes grayish olive. As the sector mutation occurs, the mycelium of the mutant is nearly white. Conidia begin to appear about 4-7 days after the cultures are incubated at 25° C. Frequently 2-4 spores are borne at the tip of a conidiophore forming a chain and between them there are hyaline connections. Most of the first conidia are obclavate, with a broad base and tapering towards the apex. The successive conidia are cylindrical, with ends of equal diameters. All the conidia are buffy brown, 3-15-septate, and measuring 47.9-208.0 × 5.9-10.9 μ. Conidiophores are Dresden brown, cylindrical with 1-3-septate, measuring

37.3-122.8 × 5.3-7.3 μ. Cross inoculations were made and all of them gave positive results.

Olive (19) placed the fungus in the genus *Helminthosporium,* owing to the catenulate nature of conidia and the occurrence of vesicles on conidia in cultures. The writer believes that these characters may be influenced, to a certain extent, by environmental factors. For vesicles on conidia are not a constant structure and conidia are produced in chains only under very moist conditions. While catenulate conidia occur in certain species of *Helminthosporium,* they also occur in *Cercospora catenospora* Atk.

This fungus, indeed, bears the characteristics of both *Cercospora* and *Helminthosporium* and is considered a border-line or an intermediate type. But most characters of its conidia, such as cylindrical shape, great length in relation to its diameter, often hyaline in color, and usually acrogenous in position, indicate closer relationship with *Cercospora* than with *Helminthosporium.* It seems inadequate to separate these two genera on the basis of such characters alone. Unless future research reveals a more valid basis for their distinction, or the perfect stage of this fungus can be found, it seems advisable to simply acknowledge Kawamura's priority and consider this fungus as *Cercospora vignicola* with *Helminthosporium vignae* reduced to synonym.

ANTHRACNOSE (1)

Except the leaves and flowers, anthracnose can infect all the aerial parts of soybean plants, but its typical and cardinal development occurs on the pods.

The disease causes the hypocotyl blight and the stem blight. The former has been observed by Ling (14) in Szechwan Province, West China. Infection first appears on cotyledons as darkened cankers and gradually extends downward to the hypocotyl. Iowa Agricultural Experiment Station (5) has reported that this disease caused the neck rot at emergence. The affected portions of the stem are covered with black scattered acervuli. The symptom somewhat resembles the pod and stem blight caused by *Diaporthe phaseolorum* var. *sojae,* but the disease is distinguishable by the irregular distribution of the fruiting bodies.

During the wet weather near harvest time, the anthracnose is very serious on the pods, and its symptom is the appearance of black, often circular spots covered with numerous black acervuli. The spots later become sunken at the center and coalesce to form irregular or extended lesions. The spots on seeds are fuscous, or fuscous-black, varying in size from a mere speck to large lesions. They may extend through the seed coat and involve the cotyledons. As diseased seeds germinate, the lesions become large, depressed and give rise to sticky spore masses.

The anthracnose is caused by *Colletotrichum glycines* Hori with *Glomerella glycines* (Hori) Lehman and Wolf as its perfect stage. The writer isolated this fungus from diseased seeds, stems and pods collected from the field in Nanking. In cultures isolated from diseased seeds, only conidia were produced. Setae are usually more abundant in older cultures, stiff, pointed, unbranched, septate, and buckthorn brown, intermingling with conidiophores. Conidia are hyaline, non-septate, sickle-shaped, 20.0-26.8 × 3.5-4.0 μ. The conidia of *Colletotrichum glycines* were found both by Hemmi (3, 4) and Lehman and Wolf (13) to be sickle-shaped. However, Nakata and Takimoto (18) listed two anthracnose fungi on soybean in Japan, namely *Colletotrichum glycines* Hori

and *Gloeosporium* sp. They erroneously described the conidia of the former as elliptic and the latter, sickle-shaped.

Perithecia were obtained by the writer in cultures isolated from diseased pods and stems. They are aggregated in groups of 3-5, submerged, black, globose, 157.3-260.4 μ in diameter, and with a membranaceous wall. Asci are clavate to oblong, straight or slightly curved, 46.2-56.8 × 9.9-13.5 μ, aparaphysate. The ascospores are hyaline, single-celled, elliptic, slightly curved, usually eight in each ascus, 13.9-23-1 × 5.6-6.9 μ. However, these cultures produced perithecia only and the morphology of the perithecia does not agree well with that of *Glomerella glycines*. The identity of the ascigerous stage observed by the writer and its connection with the conidial stage are therefore uncertain.

Pure cultures of the conidial strains were obtained from diseased seeds and their growth rates tested on potato-dextrose agar and sterilized pods. They grow well and produce conidia on these media. In most cases the rate of growth is moderate. The colony is pale smoke gray at first, then turns to chaetura black, and finally to olivaceous black (3). Sometimes 2-3 zones are distinct. The pale smoke gray aerial mycelium is very short. Acervuli which are surrounded by setae are irregularly scattered and they are white, orange-pink, grenadine in color. Other cultures of the perithecial strains were isolated from diseased stems and pods. The growth rate is rather rapid. The colony is light salmon-orange in color. Black perithecia are formed on the plate cultures in about one month at 25° C.

ANTHRACNOSE (2)

Cultures of *Gloeosporium* were also obtained from diseased seeds. In seedling inoculation, this fungus can merely affect the cotyledons and the lesions are circular or subcircular in shape and chocolate in color. Lesions on inoculated seeds are sayal brown at first, becoming clove-brown or almost black, and finally are covered with pale smoke gray mycelium with zinc orange spore-masses at its center. Mycelium may enter the seed-coat, but can not affect the surface of the cotyledon. Under natural conditions, only infected pods are found. The spots on pod start from the center or near the center of the pods and are round with a distinct, army brown margin. It rapidly enlarges. The center becomes slightly sunken and pecan brown in color, with a persistent cinnamon colored border.

This anthracnose is caused by *Gloeosporium* sp. It was reported by Nakata and Takimoto (18) in 1928 and Hara (2) in 1932. The acervuli are well developed on the affected surfaces of the diseased seeds and pods, or on the potato-dextrose agar. They are strawberry pink in color, without setae. The conidia are hyaline, straight, rarely slightly curved, non-septate, oblong, often with granular reflective bodies, when formed on the pods, 11.2-16.8 × 4.2-5.6 μ.

On the potato-dextrose agar, the growth rate is moderate. At first, hyphae grown along the surface of medium are whitish and compact, but soon turn to deep slaty brown, with an abundance of loose, whitish flocculent aerial mycelium.

PHYLLOSTICTA LEAF SPOT

This disease was found on the seeds of the Yellow-seed variety in Chengtu and Nanking It was an important foliage disease in the field near Nanking in 1945 and

1947. It is probably widely distributed in China. Its attack on seed and pod is less severe. But seed and pod lesions are the sources of primary inoculum for foliage infection.

The causal fungus, *Phyllosticta sojaccola* Massalongo, is primarily a leaf parasite and causes angular spots bounded by veins. Usually many black pycnidia are formed on the dead surface of the spots. On the seeds, the disease appears at or near the ripening stage as a snuff brown speck or patch, sometimes with numerous pycnidia in the spotted areas. Pod infections have not been observed.

In seedling inoculations with fungus isolated from seeds, cotyledons and leaves are infected; the spots on both cotyledons and leaves start from the wounds and are circular or semicircular, warm sepia or benzo brown in color. Sometimes black pycnidia are formed on the margins of the spots.

The black pycnidia of this fungus are formed on host tissues and on potato-dextrose agar, very numerous, globose to subglobose, ostiolate, with membranaceous walls. The pycnidiospores are elliptic to ovoid, hyaline, with 2-3 granules, 4.9-10.2 × 3.1-3.6 .μ

According to Miura (17) its perfect stage belongs to *Pleosphaerulina*. Black globose perithecia with a size varying from 100-110 μ in diameter are submerged in host tissues and each of them contains numerous asci; asci are broadly elliptic, 8-spored, 57-77 x 35-40 μ in size, with wall thickened at the apex; ascospores are elliptic, hyaline, muriform with 3-transverse septa and 1-2 longitudinal ones, 21-32 × 9-11 μ. It was once found in the experimental field in Chengtu on the leaf of young plants by Wei in 1941 (unpublished notes), but was not again discovered by the writer.

When the surface-sterilized diseased seeds are placed on potato-dextrose agar in Petri dishes and incubated at 25°C. for a few days there are numerous deep olive or dark grayish olive fluffy tufts of mycelium developing from the seeds. After 10 days pycnidia are formed.

Alternaria leaf spot

A species of *Alternaria* is commonly isolated from diseased seeds. Leaf-infection by the same fungus was observed in the soybean field near Nanking. Records of such occurrence (1, 6) were made in the United States. In the field, the disease often attacks the foliage, resulting in dark grayish olive or olivaceous black (1) spore masses upon mikado brown spots.

The spots on cotyledons and leaves started from the wounds when the seedlings were artificially inoculated. The lesions on cotyledon are dark olive-gray in color, with 1-3 concentric rings, and those on leaves are characterized by olive-gray, then olive yellow, and finally mikado brown color, brittle papery texture and 1-2 concentric zones.

Gibson (1) suggested that this fungus is a weak parasite and affects the host only through the wounds punctured by aphids or the sunburned areas. In artificial inoculations carried out by the writer, the fungus was able to infect healthy tissues only through needle punctures.

The leaf spot is caused by *Alternaria atrans* first described in 1922 by Gibson (1) in Arizona. In cultures, conidiophores are inconspicuous. Conidia are borne singly or in chains of 2-5 spores, oblong or obclavate, dark grayish olive to olivaceous black

(1), with or without a short beak, muriform with 3-11 transverse septa and 0-4 longitudinal ones, 29.7-57.4 × 9.9-16.5 μ.

Pure cultures of this fungus is dull greenish black (2) in color and its growth rate is rather rapid. Abundant conidia begin to appear about 5-6 days after the cultures are incubated at 25°C. The ramifying hyphae form grayish olive mass at first, and then turn to dull greenish black (2). The discoloration eventually extends through the agar medium.

Pod blight

Macrophoma pod blight was found in Chengtu and Nanking. It caused a widespread and ravaging disease of the soybean plants. The fungus is not known to attack any part of the soybean plants except the pods and seeds, but it sometimes causes extensive pod blight. In years when rains are frequent in August to October the disease becomes epiphytotic, resulting in considerable deformation of pods in September and October.

The affected pods show water-soaked lesions with a little white mycelium at first. The spots rapidly enlarge and turn dull greenish black (2). Usually the lesion is depressed, and, under wet weather, gives forth abundant white aerial hyphae which soon cover the entire pod, turn dark greenish olive and are eventually transformed into a black crust bearing black globose dots. When the seeds are artificially inoculated, the infection starts as an irregular water-soaked, natal brown lesion and is rapidly enlarging. The diseased seed-coat often has many cracks and the lesion is usually depressed and wrinkled.

The disease is caused by *Macrophoma mame* described by Hara (2) in Japanese. Numerous pycnidia are aggregated or scattered on the dull greenish black (2) lesion. They are globose to subglobose, sometimes papillate, ostiolated, and black in color, 131.6-180.2 μ in diameter. The wall of the pycnidium is at first membranaceous, then coriaceous. Conidiophores are clavate, hyaline, continuous, simple, 7.0-14.0 × 3.0-4.5 μ. Conidia are single, non-septate, hyaline, fusiform to narrowly oblong, pointed at both ends, 15.0-24.8 × 6.5-8.1 μ on host tissues, and 11.9-21.1 × 4.0-7.6 μ in cultures.

The fungus grows well on potato-dextrose agar and the mycelium covers the surface of the medium in plate, 10 cm. in diameter, in about 10 days at 25°C. The hyphae at first form a white fluffy mass, which later becomes olivaceous black (3) and, when the aerial mycelium begins to appear, it is white in color and later turns to dark greenish olive. Pycnidia are well formed in the fresh soybean pod medium, though it does not or rarely occur on the potato dextrose agar.

Diplodia black dot

A *Diplodia* which causes the pod blight of soybean was isolated from diseased seeds collected in Chengtu on Yellow-seed plants in 1945. During September 1-4, 1947, severe outbreak of blight of developing pod was observed in Wusih and Changchow on fully developed plants. The causal agent was proved by laboratory tests to be the same species of *Diplodia*.

This *Diplodia* is chiefly a parasite on soybean pods and the development of seeds in the pod is arrested by its infection. The fungus may attack the mature and the immature pods, usually the latter. In serious cases it involves the whole plant. Because the growth of the fungus is very rapid, so that no local lesion was observed; it soon

covers the whole pod, which turns pale smoke gray or light buff, and bears many black dots irregularly arranged. The seeds in the diseased pod are affected and the iron gray hyphae envelop the whole seed.

The leaves, hypocotyls, and cotyledons may be infected when the seedlings are artificially inoculated with a bit of mycelium. The lesions start from the wounds and gradually enlarge. The spots on leaves and cotyledons are tawny in color and circular in shape, and those on hypocotyls are buckthorn brown, and sometimes sunken. But in nature only infected pods and seeds were observed.

Pycnidia are formed on the surface of the pod and seed, or on the sterile soybean-pod medium along the wall of the glassware, but rarely on the potato-dextrose agar. They are black, pyriform or nearly globose, slightly immersed in the host tissues, papillate-ostiolate, with carbonaceous wall, measuring 290-392 μ high and 232-290 μ in diameter.

The pycnidiospores ooze out freely through the ostiole, if the pycnidia are placed in water on a slide. Pycnidiospores are at first non-septate, subglobose, ovate to oblong, thick walled, and hyaline. They turn Brussels brown, raw umber, or dark olive in color and become mature *in vitro*. The mature spores are typically oblong, 1-septate, slightly constricted at the septum, 16.8-28.7 × 11.9-14.0 μ. The measurements of 150 individuals averaged about 22.4 × 13.3 μ. Immature spores germinate more readily than mature ones.

The mycelium grew well on potato-dextrose agar. The growth was very rapid and covered the surface of a Petri plate in 7-8 days when held at a temperature of 25° C. The agar turned olivaceous black (1). There were some white or olive, short, fluffy aerial hyphae. Pycnidia and pycnidiospores formed on the fresh soybean-pod medium appeared identical with those formed on the host tissues.

The disease has not been reported previously and the fungus can not be identified to any species of *Diplodia* known to the writer.

Mycosphaerella leaf spot

Mycosphaerella sojae Hori was isolated from the diseased seeds collected in Chengtu and Nanking, but this leaf spot was not observed in the field in both places.

According to Yamamoto (27), this disease occasionally attacks the lower leaves, producing yellowish brown or grayish white lesions, about 1-30 mm. in diameter, circular, elliptic, or angular with brown or dark brown distinct margins. As the disease advances the spots turn slight yellow, or pale white. Finally many black dots appear at the center of the spot.

From infected seeds which are testaceous in color and usually shrivelled and cracked, the writer isolated this pathogen. In inoculation experiments the fungus did not affect any part of the soybean plants except the cotyledons. The lesion, starting from a wound, results into cacao brown circular spot about 3-4 days after the inoculation and gradually enlarges and turns to cameo brown.

Perithecia formed in cultures are black, globose, or subglobose, singly or in groups, shortly papillate, ostiolate, 40-88 μ in diameter; asci are hyaline, clavate to cylindric, 8-spored, sometimes slightly curved at the apical end, 28-40 × 9-13 μ; ascospores are hyaline, elliptic, with pointed ends, 2-celled, 11-16 × 4-6 μ.

On potato-dextrose agar, its rate of growth is moderate and perithecia begin to appear after an incubation at 25°C. for 10-14 days, superficially on the medium. The deep mouse gray aerial hyphae are well developed, uniformly dense, fluffy, but very short.

RHIZOCTONIA ROOT ROT

Rhizoctonia solani Kühn was isolated from discolored seeds. On inoculation, the seedlings are usually infected through the wounds, producing, after 4-7 days, liver brown or carob brown spots on the cotyledons and cinnamon-rufous lesions on the hypocotyls. Sometimes the hypocotyls may break at the lesions. The seeds infected in artificial inoculation showed mars brown or mummy brown, irregular patches, with a few gaping cracks.

Johnson and Koehler (6) reported this fungus to cause a root rot of soybean plants. In severe cases about half of the plants were killed prematurely. But in China the disease has not been reported to occur in the field; only Wei (24) stated that the rice isolate can infect the soybean plants in artificial inoculations. The fungus was studied by many investigators. The more recent study of Tervet and Tsiang (22), in which 13 isolates from sugar cane, potato, rice, pea, bean, tomato, eggplant, and sugar beet, were tested for pathogenicity on soybeans, indicated that the bean, tomato, and eggplant isolates were pathogenic to soybean.

The mycelium is russet in older cultures, and has a length of 100-200 μ between two septa and a width of 8-11 μ. In young cultures it is buckthorn brown in color and produces abundant cottony aerial growth. Its growth is very rapid, covering a Petri dish, at the temperature of 25° C., in 4 days. After 7-9 days, it forms white, irregular sclerotia which turn into buckthorn brown or russet in color.

HELMINTHOSPORIUM LEAF SPOT

Form the diseased seeds collected in Nanking, a typical *Helminthosporium* was isolated, but no specimens were collected on leaves or stems from the field, although inoulation tests on seedlings showed that this fungus is pathogenic to the foliage.

The fungus attacks leaves, cotyledons, and hypocotyls, but spots are only numerous on leaves. The spots on leaves and cotyledons are snuff brown, cinnamon-buff, or clay color and circular in shape, and those on hypocotyls are blackish brown (3) and sunken. Sometimes the affected hypocotyls break off at the lesions as the disease advances.

This *Helminthosporium* is not yet described in literature. Conidiophores and conidia are formed in potato-dextrose agar at a rather low temperature. Conidiophores are usually simple, erect, sometimes more or less geniculate above, bister to brownish olive in color, becoming lighter toward the tip where it may be nearly hyaline, measuring 181.5-227.7 × 5.3-6.3 μ. The scars, marking the attachment of spores, are rather conspicuous. Conidia are born successively at intervals, oblong to obclavate, mostly straight or curved, 3-9-septate, buffy brown to olive-brown, measuring 30.0-100.1 × 10.9-16.8 μ.

Mycelium grows very slowly on potato-dextrose agar, and hyphae are delicate, septate, hyaline when young, becoming olivaceous black (3) and forming a dark

olivaceous flocculent mat at the surface of the agar. This dark olive gray coloration somewhat extends through the agar medium.

In the preceding descriptions, several seed-inhabiting bacteria and fungi were left out, especially several pathogenic *Fusaria*. Of these, no effort has been made to study its identity. *Peronospora manshurica* (Naoum.) Sydow is an obligate parasite and is transmitted by seeds as demonstrated by several investigators (Wolf and Lehman (26) and Johnson and Koehler (6)). *Septoria glycines* Hemmi and *Cercospora daizu* Miura, the former causing a brown spot disease and the latter, a frog-eye spot, were reported as seed-borne fungi by Wolf (25) and Lehman (11, 12) respectively, but were not encountered in this isolation experiment. It may be that these fungi are absent or rare in Chengtu and Nanking.

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FURTHER STUDIES ON THE CHANGE OF CARBOHYDRATES OF GERMINATING WHEAT SEEDS IN THE MANGANESE SULPHATE AND INDOLE-ACETIC ACID SOLUTIONS

CHEN-CHUNG KING

In the writer's previous paper it was found that in the endosperm of germinating wheat seeds, manganese sulphate accelerates the activity of amylase and the rate of translocation and utilization of foods, whereas indole-acetic acid behaves in a quite different way. Unlike manganese sulphate, indole-acetic acid accelerates the activity of amylase only at the beginning of germination, and inhibits the translocation and utilization of food substances throughout the early period of growth (2). The same conclusion was drawn by Loo and Ni (4) and Loo, Huang and Ni (3) of our laboratory. However, further experiments dealing with the translocation and utilization of foods are desirable. The present study is an outcome of such needs. The results of this work are a direct answer to the question about the effect of manganese sulphate and indole-acetic acid on the translocation and utilization of foods, and incidentally confirm the previous findings on the starch hydrolysis in the presence of these two chemicals but with longer duration than in the previous work.

MATERIALS AND METHODS

In order to exclude as completely as possible the variability of the seedlings during germination, all seeds were carefully selected before the experiment as in the previous work. Wheat seed of Che Ta 15-62-2 was used, which grows uniformly under natural condition.

Twenty-one 250 ml. Erlenmeyer flasks were divided into three groups of 7, containing a definite quantity of manganese sulphate, indole-acetic acid and redistilled water respectively. Flasks containing redistilled water served as the control. The concentration of the test solutions was 10^{-6} molar.

In order to maintain the duration of experiment as long as 14 days, it was necessary to have a sufficient quantity of test solution in the flask. But seed germination in a waterlogged condition is not the way of obtaining uniform seedlings. For this purpose, some specially designed curved glass rods were placed at the bottom of the Erlenmeyer flask. Filter paper was spread over these glass rods. Wheat seeds were placed on the filter paper under strictly aseptic conditions. Then germination was allowed to take place in an incubator at 22 ± 0.5°C.

All the processes of sterilization were the same as that described in the previous paper.

Samples were taken at an interval of 48 hours. Forty-eight hours after the beginning of the germination, all the seedlings were taken out of the flask, 50 for each treatment. The roots and shoots were cut off immediately and placed together with the detached grains in a drying oven at 100°C. for 20 minutes to stop enzyme action. Then the samples were dried to constant weight in a drying oven at 70°C. and were weighed in weighing bottles. They were kept for chemical analysis which involved the estimation of reducing sugar, non-reducing sugar, starch and dextrin. The technique of analysis used was the same as in the previous work, being the Munson-Walker-Bertrand method modified by Loomis and Shull (6).

EXPERIMENTAL RESULTS

Changes of Carbohydrates in the Grains

In the previous paper, it was found that starch hydrolysis in the germinating seed was actually quicker in manganese sulphate solution than in redistilled water. But in the indole-acetic acid medium, the starch digestion was stimulated at the very beginning of the germination, as the experiment went on, however, an inhibiting effect developed instead of stimulating. These facts were confirmed by the present data shown in table 1.

TABLE 1. CARBOHYDRATE CONTENTS IN GRAINS AT SUCCESSIVE STAGES OF GERMINATION (MG./50 GRAINS)

Days after germination	Medium	Reducing sugar	Non-reducing sugar	Total sugar	Starch and dextrin	Carbo-hydrates
	Control	15.6	2.8	18.4	913.5	931.9
2	$MnSO_4$	16.1	7.5	23.6	805.5	829.1
	IAA*	16.9	5.2	22.1	902.6	924.7
	Control	25.2	4.3	29.5	688.5	718.0
4	$MnSO_4$	38.8	6.6	45.4	551.7	597.1
	IAA	26.3	3.8	30.1	663.8	693.9
	Control	36.8	11.6	48.4	295.2	343.6
6	$MnSO_4$	46.1	6.5	52.6	261.0	313.6
	IAA	31.8	5.4	37.2	304.2	341.4
	Control	66.0	9.6	75.6	44.1	119.7
8	$MnSO_4$	86.9	7.6	94.5	41.4	135.9
	IAA	54.5	7.8	62.3	56.7	119.0
	Control	22.5	13.3	35.8	17.6	53.4
10	$MnSO_4$	34.2	11.1	45.3	9.5	54.8
	IAA	16.2	9.8	26.0	31.5	57.5
	Control	6.5	5.8	12.3	1.1	13.4
12	$MnSO_4$	11.3	4.1	15.4	1.1	16.5
	IAA	4.8	1.0	5.8	2.8	8.6
	Control	0	4.9	4.9	0	4.9
14	$MnSO_4$	0	2.0	2.0	0	2.0
	IAA	0	2.1	2.1	0	2.1

*IAA represents indole-acetic acid.

It is noteworthy that the amount of reducing sugar in manganese sulphate set was substantially much greater than that in either the indole-acetic acid or the control. No difference between the control and indole-acetic acid was observed before the 4th day, but from this time on, the amount of reducing sugar in the former was apparently higher than that in the latter. The influence of manganese sulphate and indole-acetic acid on the amount of the non-reducing sugar was of a similar degree. Both increased at the beginning and decreased after the 4th day.

Evidently, sugars were derived from the decomposition of reserved starch by the action of amylase during germination. Manganese sulphate accelerated the hydrolysis of starch to such an extent that throughout the experiment the starch content in the grain was always the least. On the other hand, the digestion of starch in the indole-acetic acid medium was quite rapid before the 4th day but became slow later. This trend may be obviously seen from the amount of total sugars remaining in the grains as shown in the fifth column of table 1—that is, highest content of total sugar occurred in the grains treated with manganese sulphate, the next in the control, and, except at the very beginning, the lowest in the indole-acetic acid medium.

The last column in table 1 shows the changes of carbohydrates in the grains throughout the 14 days. From the beginning to the 6th day, the effect of treatment with manganese sulphate is very conspicuous, carbohydrates being rapidly consumed. From the 6th day on, no significant difference of carbohydrate consumption could be seen between manganese sulphate treatment and the control. In case of the indole-acetic acid treatment, a slight loss in carbohydrates occurred during the early period of the experiment. There was no noticeable difference in carbohydrate consumption between such treated grains and the control during the later days.

Changes of Carbohydrates in Shoots and Roots

Since the seedlings were grown in the dark, all sugars in the shoots and roots must have come from the grains. This involves the rate of translocation of foods which may be determined by estimating the soluble carbohydrates in the shoots and roots. The analysis began with the samples taken on the 4th day, because the size of shoots and roots were so small at the second day that an accurate chemical analysis of the sugars was not possible. In table 2, the amount of starch and dextrin were not recorded, since iodine test failed to show the presence of these materials in the fresh sample.

(1) Shoots. In manganese sulphate medium, the amounts of reducing sugar and non-reducing sugar and hence the total sugar were consistently higher than those in the redistilled water and the indole-acetic solution. The amount of non-reducing sugar of the shoots grown in the indole-acetic acid medium, however, always surpassed that in the redistilled water. As to the amount of reducing and total sugars between shoots grown in the media of indole-acetic acid and redistilled water, there was no marked difference.

(2) Roots. Except the 4th day, the amount of reducing sugar in roots grown in the manganese sulphate solution remained more or less the same as that of the control. But the non-reducing sugar content was remarkably greater in the case of manganese sulphate than in the control. On the other hand, the amount of reducing sugar in the roots of indole-acetic acid treated plants was the lowest among these three

lots. Although the content of non-reducing sugar surpassed that of the control during the first 8 days, it became less than that of the control thereafter. Consequently, as shown in the 8th column of table 2, the content of total sugar was greatest in the manganese sulphate treated roots and lowest in those treated with indole-acetic acid.

TABLE 2. CARBOHYDRATE CONTENTS IN VEGETATIVE PARTS AT SUCCESSIVE STAGES OF GERMINATION (MG./50 GRAINS)

Days after germination	Medium	Shoots			Roots			Total
		Reducing sugar	Non-reducing sugar	Total sugar	Reducing sugar	Non-reducing sugar	Total sugar	
	Control	30.7	8.1	38.8	20.2	3.8	24.0	62.8
4	$MnSO_4$	68.6	112.2	180.8	12.2	27.7	39.9	220.7
	IAA	20.9	16.3	37.2	11.0	11.0	22.0	59.2
	Control	33.3	5.5	38.8	25.6	6.0	31.6	70.4
6	$MnSO_4$	45.0	7.2	52.2	22.4	16.3	38.7	90.9
	IAA	43.5	6.3	49.8	10.3	10.2	21.2	71.0
	Control	44.8	0.5	45.3	23.3	3.4	26.7	72.0
8	$MnSO_4$	54.4	6.2	60.6	21.1	15.9	37.0	97.6
	IAA	47.0	2.5	49.5	11.1	11.5	22.6	72.1
	Control	28.7	2.6	31.3	24.7	11.9	36.6	67.9
10	$MnSO_4$	36.8	6.9	43.7	28.2	13.1	41.3	85.0
	IAA	31.5	6.1	37.6	17.7	9.7	27.4	65.0
	Control	26.8	0.4	27.2	10.0	2.5	12.5	39.7
12	$MnSO_4$	30.0	1.3	31.3	12.6	3.4	16.0	47.3
	IAA	26.5	4.8	31.3	3.4	0.6	4.0	35.3
	Control	21.4	0.5	21.9	10.0	6.1	16.1	38.0
14	$MnSO_4$	22.6	0	22.6	10.5	7.6	18.1	40.5
	IAA	19.6	0.7	20.3	9.0	4.2	13.2	33.5

CHANGES IN DRY WEIGHT OF SHOOTS, ROOTS AND GRAINS

The data for the dry weight of shoots, roots and grains are shown in table 3. In this table the replications was three for all sets of data and only the mean value was presented. They were submitted to statistical treatment by the analysis of variance (1), and the results are summarized in table 4. The significant difference at the 5% and 1% point level for comparison of means of three are given in the supplement at the end of table 3.

From table 4, it is obvious that the F value of the medium and the interaction between medium and age were insignificant. This fact showed that at least under the present experimental condition, no matter how the medium were applied, their effects on the dry weight were the same, and did not depend upon the age to which it was applied. However, it may be noted that the F-test was applied only to the values for seven 48-hour intervals as a whole. When comparisons were made with individual means of three of every 48-hour interval, there were some significant differences.

TABLE 3. MEAN DRY WEIGHT OF THREE REPLICATIONS IN WHOLE PLANTS AT SUCCESSIVE STAGES OF GERMINATION (MG./50 GRAINS)

Days after germination	Medium	Shoots	Roots	Vegetative part	Grains	Whole plants
	Control	20.0	27.7	47.7	1531.3	1579.0
2	$MnSO_4$	21.7	27.3	49.0	1494.3	1543.3
	IAA	18.0	24.7	42.7	1520.7	1563.4
	Control	200.3	133.0	333.3	1179.3	1512.6
4	$MnSO_4$	216.0	141.3	357.3	1118.3	1475.6
	IAA	189.7	120.7	310.4	1161.0	1471.4
	Control	383.3	250.0	633.3	743.3	1376.6
6	$MnSO_4$	386.0	273.3	659.3	690.3	1349.6
	IAA	392.7	244.0	636.7	700.7	1337.4
	Control	471.0	281.3	752.3	475.3	1227.6
8	$MnSO_4$	468.3	283.0	751.3	463.3	1214.6
	IAA	440.0	275.0	715.0	466.0	1181.0
	Control	487.0	310.0	797.0	308.3	1105.3
10	$MnSO_4$	511.7	309.7	821.4	283.0	1104.4
	IAA	486.0	306.7	792.7	291.7	1084.4
	Control	493.7	325.7	819.4	238.3	1057.7
12	$MnSO_4$	498.7	324.0	822.7	233.3	1056.0
	IAA	490.7	299.3	790.0	239.7	1029.7
	Control	487.7	311.7	799.4	203.0	1002.4
14	$MnSO_4$	497.7	304.7	799.4	187.0	986.4
	IAA	475.7	302.3	788.0	191.3	979.3
Significant diff.	(5%)	13.6	23.6	33.1	30.1	30.7
	(1%)	18.1	31.6	44.2	40.2	41.1

TABLE 4. F AND P VALUE FOR TREATMENTS

Seedling	Treatments	F	P
	Medium	1.8	> 0.05
Shoots	Age of seedling	474.4	< 0.01
	Age x Medium	< 1	> 0.05
	Medium	< 1	> 0.05
Roots	Age of seedling	76.7	< 0.01
	Age x Medium	< 1	> 0.05
	Medium	1.3	> 0.05
Vegetative part	Age of seedling	283.1	< 0.01
	Age x Medium	< 1	> 0.05
	Medium	2.0	> 0.05
Grains	Age of seedling	99.5	< 0.01
	Age x Medium	< 1	> 0.05
	Medium	2.1	> 0.05
Whole plant	Age of seedling	184.5	< 0.01
	Age x Medium	< 1	> 0.05

Data in the third and fourth columns of table 3 show that dry weight of shoots in the manganese sulphate solution was slightly greater than that in the control, but that of roots was similar to each other. In the indole-acetic acid solution, on the contrary, the dry weights of both shoots and roots were less than those in the control and manganese sulphate solution. The lowest dry weight of vegetative part in the indole-acetic acid medium was even more obviously shown in the 5th column. These facts lead to the conclusion that in the concentration of 10^{-6} molar manganese sulphate and indole-acetic acid media, the former tends to promote growth, while the latter, to retard. This is in good agreement with the results obtained by Loo and Tang (5).

The decrease in dry weight of grains germinated in the manganese sulphate solution was very apparent from the beginning to the end of the experiment. The difference between these and those of the control was significant at the 5% point level before the 4th day, but became insignificant thereafter. It must be noted that these facts involve the rate of translocation and respiration. The more the food was translocated to the shoots and roots or the more it was consumed by the plants, the greater the loss of dry weight must be in the grains.

From the data in the last column of table 3, it may be seen that the dry weight of the whole plants either grown in manganese sulphate solution or in indole-acetic acid solution was less than that of the control. The actual data in the case of indole-acetic acid was even lower than that in the manganese sulphate. This phenomenon is noteworthy, because it shows that both chemicals, especially the indole-acetic acid, stimulate to some extent the respiration intensity of the seedlings.

DISCUSSION

The works of Loo and Ni, King, and Loo, Huang and Ni prove that the effect of manganese sulphate on the starch hydrolysis in plant tissues is very favorable. The more sugar is produced as a result of rapid hydrolysis of starch, the more it is utilized and translocated under the influence of this chemical. The data of the present paper indicate that the presence of manganese sulphate not only accelerates the rate of starch hydrolysis, the rate of translocation of foods, but also promotes the growth of seedling and the rate of respiration. The last point is in good accord with the general idea of Lundegardh (7).

In the case of plants grown in the indole-acetic acid medium, sugar content was nearly equal to that of the control, especially in the shoot the amount of sugar was even somewhat greater than that of the control. In view of the fact that starch hydrolysis in the indole-acetic acid treated grains was superior to that of the control and that the growth of seedlings was rather poor, it seems logical to conclude that the translocation of the decomposition product of starch in this case was by no means bad. In other words, under present experimental condition, indole-acetic acid did not retard in any appreciable manner the transport of sugars from endosperm to shoots and roots as we had expected in a previous paper.

In spite of the deposit of plenty materials available for the construction of plant body, the plant growth occurring in the indole-acetic acid solution was not good. Under the influence of indole-acetic acid, the plant was either unable to resynthesize the

decomposition product of the reserve materials or was in lack of some materials necessary for the synthesis. At any rate, in the presence of indole-acetic acid, the plant failed to utilize the available sugars for constructive purpose.

During the experimental interval, greatest loss of weight occurred in the case of plants grown in the indole-acetic acid solutions. Since there was no photosynthesis and supply of food, loss of weight due to respiration was inevitable. Thus it comes to the conclusion that indole-acetic acid stimulates the respiration of wheat plants. From the fact that more reducing sugar and total sugar were found in the shoot than in the root, it may be safely concluded that the parts of plant which are directly in contact with the indole-acetic acid solution respire more intensely than the rest.

SUMMARY

Studies on the changes of carbohydrates in germinating wheat seeds cultured respectively in the manganese sulphate solution, indole-acetic acid solution and redistilled water were carried out. Determination of dry weight and analyses of reducing sugar, non-reducing sugar, and starch and dextrin fractions in shoots, roots and grains at an interval of 48 hours were undertaken.

The results show that starch hydrolysis, respiration and translocation of foods were all accelerated by manganese sulphate.

In the presence of indole-acetic acid, starch digestion was promoted at the beginning of the experiment, but as the experiment went on, it was retarded. Translocation of sugar under the influence of indole-acetic acid was found quite normal. Indole-acetic acid stimulated the respiration of wheat seedlings, especially the root.

The effects of both chemicals on the early growth were not very significant. But growth in manganese sulphate solution was definitely better than that in the indole-acetic acid medium. The latter was even inferior to that of the control.

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THE EFFECT OF MANGANESE SULPHATE AND INDOLE-3-ACETIC ACID IN DIFFERENT CONCENTRATIONS ON THE STARCH DIGESTION IN GERMINATING WHEAT SEEDS

TSIN-SHAN NI

In a previous paper, Loo and Ni (5) reported that the increase of amylase activity in wheat seeds can be brought about by treating the latter with manganese sulphate solution. The present work is a continuation of the former, dealing with the effect of different concentrations of manganese sulphate and indole-3-acetic acid on the starch digestion.

MATERIAL AND METHOD

Wheat seeds of uniform size were selected. After being washed with 80% alcohol for 15 minutes, they were sterilized in 0.1% mercuric chloride solution for the same interval, then washed with sterile distilled water and finally with sterile redistilled water. The seeds were germinated on filter paper disks in sterilized cotton plugged test tubes. Three grains were put in each tube containing five ml. of test solution. Germination was allowed to proceed in an incubator. Sampling and tests were carried out daily.

Starch grains of the germinating seed were pressed out from the endosperm into 10% glycerine. Drops of starch-glycerine suspension were mounted on slides. Grains of approximately same size, corroded or non-corroded, were counted under microscope.

After corrosion of starch grains has completed, sap expressed from the endosperms was tested with iodine potassium-iodide solution every day. The color reaction was observed by placing the slide on a porcelain plate. Absence of starch-iodine color was considered as the disappearance of starch in the endosperms of seedlings. The date of the disappearance of starch-iodine color was recorded.

EXPERIMENTAL RESULTS

The results of experiment dealing with the corrosion of starch grains are summarized in table 1. About 90% of starch grains was corroded in seeds germinated in 10^{-6} M manganese sulphate solution at the fourth day. In a solution of indole-3-acetic acid of the same concentration, the percentage of corroded grains was only 52.9. At the same time, 53.4% of corroded grains was observed in the control. It seems that the accelerating effect of manganese sulphate on amylase activity was more conspicuous. The percentage of corrosion in 10^{-6} M indole-3-acetic acid was the same as that of control. In the early period of the experiment, the influence of manganese sulphate on amylase activity was also superior to that of indole-3-acetic acid. In this period, indole-3-acetic acid slightly retarded starch grain corrosion as compared with the control.

The accelerating effect of manganese sulphate in higher concentration of 10^{-5} M did not become evident till the fifth day of the experiment. On the other hand, the percentage of corrosion in 10^{-5} M indole-3-acetic acid solution was definitely lower than that of the control. The noteworthy fact is that manganese sulphate promoted starch digestion even in a high concentration of 10^{-4} M, while indole-3-acetic acid in the same concentration appreciably retarded it, especially in the first five days.

TABLE. 1. EFFECTS OF MANGANESE SULPHATE ($MnSO_4$) AND INDOLE-3-ACETIC ACID (IAA) SOLUTIONS UPON THE STARCH GRAIN CORROSION OF WHEAT SEEDS. CONTROL WITH REDISTILLED WATER (H_2O).

Solu. used	Conc. (M.)	Time (day)	Temp. (C.)	pH initial	pH final	No. of grain counted	No. of grain corroded	Percentage of corrosion
		2				403	44	10.9
		3				498	162	32.5
H_2O		4	24°–26°	7.4	5.4	548	293	53.4
		5				551	458	83.1
		6				298	293	98.3
		2				533	31	5.8
		3				508	102	20.0
	10^{-4}	4	26°–29°	5.4	5.6	619	285	46.0
		5				485	297	61.2
		6				355	354	99.9
		2				417	49	11.7
		3				414	78	18.8
IAA	10^{-5}	4	24°	5.4	5.4	459	166	36.1
		5				545	289	53.0
		6				466	443	95.0
		2				525	38	7.2
		3				483	134	27.7
	10^{-6}	4	24°–26°	5.4	5.2	518	274	52.9
		5				611	518	84.8
		6				73	70	95.9
		2				438	52	11.8
		3				540	193	35.7
	10^{-4}	4	26°–29°	6.0	4.8	732	522	71.3
		5				530	440	83.0
		6				599	599	100.0
		2				420	52	12.3
		3				425	96	22.5
$MnSO_4$	10^{-5}	4	24°	6.0	5.0	389	167	42.9
		5				415	393	94.7
		6				342	331	96.7
		2				378	54	14.2
		3				399	135	33.8
	10^{-6}	4	24°–26°	6.0	5.2	418	375	89.7
		5				270	270	100.0

Early appearance of complete corrosion of starch grains may be attributed to the presence of large amount of amylase or to the increase in amylase activity. In the present experiment, complete corrosion occurred in the 10^{-6} M manganese sulphate solution at the fifth day. In 10^{-4} M solution either of manganese sulphate or of indole-3-acetic acid, it occurred at the sixth day. Starch grains from seeds germinated in the 10^{-5} M and 10^{-6} M indole-3-acetic solutions, about 5% of the grains remained intact.

It may be mentioned here that while counting the corroded starch grains under the microscope, corrosion was found to begin on the surface of starch grains as small depressions, gradually enlarging into pits and cavities. In the manganese sulphate treated samples, the depressions were generally deeper and cavities larger than those on the starch grains treated with indole-3-acetic acid or pure water. At the same time, numerous minute fragments were always found in the case of manganese treated samples, showing complete decomposition of starch grains. The large amount of dissolved portions and great rate of decomposition of starch grains reveals the accelerating effect of manganese sulphate upon the activity of amylase.

If the test solutions were to have any influence on the amylase activity, the rate of hydrolysis of starch should be accelerated or slackened, since starch digestion in a germinating seed is a result of amylase activity. Observations were made to ascertain this assumption. The results are summarized in table 2. Starch-iodine color was taken

TABLE 2. EFFECTS OF MANGANESE SULPHATE ($MnSO_4$) AND INDOLE-3-ACETIC ACID (IAA) SOLUTION UPON THE DISAPPEARANCE OF STARCH IN THE ENDOSPERM OF WHEAT SEEDLINGS. COTROL WITH REDISTILLED WATER (H_2O). TEMP. 2J °C.

Solu. used	H_2O	IAA 10^{-4}M	IAA 10^{-5}M	IAA 10^{-6}M	$MnSO_4$ 10^{-4}M	$MnSO_4$ 10^{-5}M	$MnSO_4$ 10^{-6}M
Date of disappearance of starch (day)	9	11	10	10	10	8	8

as a criterion in determining the presence of starch. Eight days after beginning of the experiment, starch disappeared from the endosperms of the seedlings in 10^{-5} M and 10^{-6} M manganese sulphate solution. In the control set, however, starch disappeared on the nineth day. It was hydrolyzed slowly in the seedlings which germinated in 10^{-4} M manganese sulphate. In the corresponding indole-3-acetic acid solutions, amylase activity was inhibited, as starch did not completely disappear till the tenth day. The latest disappearance of starch occurred to 10^{-4} M indole-3-acetic acid solution. From these results, it seems that manganese sulphate even in low concentrations definitely increases amylase activity, while manganese sulphate of high concentration and indole-3-acetic acid of any concentration exerted little effect upon amylase activity. Indole-3-acetic acid in high concentration even retarded.

DISCUSSION

Loo (3) and Loo and Tang (6) found that manganese sulphate in concentrations less than 10^{-3} M always accelerated the germination and exerted some beneficial effect on the early growth of crop plants. Indole-3-acetic acid in the same range of concentration was found to be detrimental. King (2) showed that manganese sulphate accelerated the digestion and utilization of starch in wheat seedlings. He also found that indole-3-acetic acid accelerated the activity of amylase at the beginning of germination but inhibited the translocation and utilization of foods and the rate of consumption

of food substance so that it caused retardation of the hydroysis of starch and dextrin. In 1947, Loo, Huang and Ni (4) reported that the presence of manganese and zinc favored starch hydrolysis in the bean leaves in the dark. Braun (1) showed that manganese chloride increased the activity of dialyzed malt diastase up to an ionic strength of 0.3, and also proved that the metallic ion, such as manganese and zinc, strongly influenced diastase activity. The present work seems to confirm the above mentioned results. In manganese treated seedlings, rapid corrosion of starch grains and early disappearance of reserved starch were observed with the exception of a high concentration of 10^{-4} M. But the influence of indole-3-acetic acid differed somewhat from that of manganese.

During the early period of germination, as a result of amylase activity, the starch is rapidly dissolved into soluble carbohydrates to meet the rapid growth of plants. Manganese sulphate activates amylase. Large amount of dissolved carbohydrate is made available for the embryo. The beneficial effect of manganese sulphate on the germination and early growth of crop plants may be attributed to these chemical changes.

SUMMARY

Wheat seeds were germinated in manganese sulphate and indole-3-acetic acid solutions of different concentrations under aseptic conditions. The corrosion of starch grains and disappearance of starch in the endosperm were observed daily.

Manganese sulphate in low concentrations accelerated amylase activity, while low concentrations of indole-3-acetic acid, did not exert any effect on starch digestion, 10^{-5} M and 10^{-6} M solution of indole-3-acetic acid definitely retarded starch digestion.

The writer wishes to express his thanks to Professor T. L. Loo for his kind direction and valuable criticism.

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THE EFFECT OF MANGANESE SALTS ON SEED GERMINATION AND EARLY GROWTH OF ZEA MAYS L.

Y. W. Tang and T. L. Loo

Although the presence of manganese sulphate in traces has been proved to be essential for or stimulatory to the growth of many plants (10, 4, 5, 9, 8, 11, 1, 12), still the nature of its action is not well understood. In an earlier paper, Tang and Yao (13) have reported that agar blocks containing manganese sulphate, when placed unilaterally on decapitated *Avena* coleoptiles, will induce curvature similar to those induced by auxins. Loo (6) has reported that manganese sulphate in the concentration range of 1-50 mg. per liter exerts favorable effect on germination and early growth of rice. The presence of manganese increases the percentage of germination, the elongation of the shoot and of the root, and also the accumulation of dry material. In the present paper similar experiments on the effect of manganese salts on the germination and early growth of *Zea mays* will be reported.

Three different manganese salts were used; manganese sulphate, manganese chloride and manganese nitrate. The chemicals used were of c. p. quality. Corn (*Zea mays* L.) seeds were chosen as the test material because they have been previously found by the authors (7) to be quite sensitive to application of manganese sulphate. Length measurements and dry weights were taken in each experiment on seedlings fixed in chrome-acetic solution.

RESULTS

Experiment 1.

The corn seeds were first soaked in distilled water for an hour and then sterilized with 3% formaldehyde solution for 10 minutes. They were washed in sterilized distilled water three times. Before being put into Petri dishes for germination, they were washed further twice, either with their appropriate test solution or with redistilled water in the case of the controls. In each sterile Petri dish containing 15 cc. of test solution, 53 seeds were placed. Each salt was tested at concentrations of 10^{-3} and of 10^{-4} molar. In the controls, redistilled water was used. The number of seeds germinated was counted as soon as the seeds began to germinate. On the fifth day of the experiment, 50 seedlings were selected out of the triplicate Petri dishes of each test and transferred into two tall porcelain vessels (8×12 cm.) containing 15 cc. of fresh test solution for further observation. Fresh solutions were added as necessary. All of the germination and early growth were allowed to take place in a dark room. The results are summarized in tables 1, 2 and 3. In these tables as well as those to follow, the percentage of germination values are the average of triplicate determinations.

The percentage germination in any manganese salt solution of either concentration appeared to be slightly greater than that of the control. Of these two concentrations, 10^{-3} molar was found to be decidedly more favorable than 10^{-4} molar with the exception that with manganese chloride a higher percentage germination occurred in the 10^{-4} molar solution. The third column of each table gives the results of

the length measurements of the seedlings at the end of each experiment. Each value represents the mean from 50 plants. In the case of the roots, the longest root of each plant was measured. The percentage of increase was, in root length as a result of treatment, 53.4 for manganese sulphate, 27.9 for the chloride and 44.9 for the nitrate all in the concentration of 10^{-3} molar (table 4). In the lower concentration, however, no increase of root length appeared as a result of treatment. It would also appear from table 4 that, at concentration of 10^{-3} molar, treatment with manganese salts also results in increased shoot length amounting to 20.0 per cent in the case of the sulphate, 14.1 per cent in the case of the chloride and 24.5 per cent in the case of the nitrate. Manganese salts in the lower concentration (10^{-4} molar) do not seem to have had any effect.

Increases of root and shoot dry weight were also obtained as a result of treatment with 10^{-3} molar manganese salts as shown in tables 1, 2 and 3.

From the results presented, it appears that both manganese chloride and manganese nitrate as well as manganese sulphate may promote the growth of corn. Of the two concentrations used, 10^{-3} and 10^{-4} molar, the former appears to be more effective.

TABLE 1. GERMINATION AND EARLY GROWTH OF CORN IN 10^{-3} AND 10^{-4} MOLAR MANGANESE SULPHATE SOLUTIONS. THE LENGTH AND THE DRY WEIGHT OF SEEDLING WERE DETERMINED AT THE END OF THE EXPERIMENT (194 HOURS). TEMPERATURE CA. 18° C.

Medium	Percentage germination after 66 hr.	Length (mm.) of seedlings (mean of 50)		Dry weight of 50 seedlings (mg.)	
		Root	Shoot	Root	Shoot
Control	79.82	49.6	44.8	363.1	523.5
10^{-3} molar	89.90	76.1	53.8	513.2	544.7
10^{-4} molar	88.00	53.8	44.4	402.1	510.6

TABLE 2. GERMINATION AND EARLY GROWTH OF CORN IN 10^{-3} AND 10^{-4} MOLAR MANGANESE CHLORIDE SOLUTIONS. THE LENGTH AND THE DRY WEIGHT OF SEEDLING WERE DETERMINED AT THE END OF THE EXPERIMENT (209 HOURS). TEMPERATURE CA. 17° C.

Medium	Percentage germination after 66 hr.	Length (mm.) of seedlings (mean of 50)		Dry weight of 50 seedlings (mg.)	
		Root	Shoot	Root	Shoot
Control	52.17	49.4	40.2	379.2	518.0
10^{-3} molar	57.02	63.2	45.9	407.3	541.7
10^{-4} molar	61.60	54.6	43.5	375.1	471.1

TABLE 3. GERMINATION AND EARLY GROWTH OF CORN IN 10^{-3} AND 10^{-4} MOLAR MANGANESE NITRATE SOLUTIONS. THE LENGTH AND THE DRY WEIGHT OF SEEDLING WERE DETERMINED AT THE END OF THE EXPERIMENT (305 HOURS). TEMPERATURE CA. 13° C.

Medium	Percentage germination after 68 hr.	Length (mm.) of seedlings (mean of 50)		Dry weight of 50 seedlings (mg.)	
		Root	Shoot	Root	Shoot
Control	70.44	35.6	30.5	314.1	556.3
10^{-3} molar	82.54	51.6	38.0	382.8	654.4
10^{-4} molar	78.62	43.2	36.7	355.0	638.2

TABLE 4. THE INCREASE PERCENTAGE OF LENGTH AND DRY WEIGHT OF SEEDLING GROWN IN 10^{-3} MOLAR MANGANESE SALTS SOLUTION CALCULATED FROM TABLES 1, 2, AND 3.

Manganese salt	Increase percentage over control			
	Length of seedling		Dry weight of seedling	
	Root	Shoot	Root	Shoot
$MnSO_4$	53.4	20.0	41.3	4.0
$MnCl_2$	27.9	14.1	7.4	4.5
$Mn(NO_3)_2$	44.9	24.5	21.8	17.6

EXPERIMENT 2.

Earlier work has shown (7) that when wheat seeds are pretreated with manganese sulphate solution (100—150 mg. per liter) and then placed in Petri dishes containing pure water, the seeds germinate faster and grow more rapidly than the untreated seeds. It was therefore of interest to treat corn seeds with different manganese salt solutions prior to germination.

Corn seeds were soaked in distilled water for an hour and then sterilized with 3% formaldehyde solution for 10 minutes. After a wash with redistilled water they were treated with a solution of a manganese salt of the desired kind for 24 hours, the concentrations varying from 10^{-1} to 10^{-3} molar. The treated seeds were again washed with redistilled water three times and were then put into Petri dishes containing 15 cc. of redistilled water. Percentage germination was observed after varying periods and the early growth of selected seedlings was measured, as described above. The results are presented in tables 5, 6 and 7.

TABLE 5. GERMINATION AND EARLY GROWTH OF CORN IN REDISTILLED WATER AFTER SOAKING WITH VARIED CONCENTRATION OF MANGANESE SULPHATE. THE LENGTH AND DRY WEIGHT OF SEEDLING WERE DETERMINED AT THE END OF THE EXPERIMENT (168 HOURS). TEMPERATURE CA. 19° C.

Seeds soaked with	Percentage germination after 66 hr.	Length (mm.) of seedlings (mean of 50)		Dry weight of 50 seedlings (mg.)	
		Root	Shoot	Root	Shoot
Control	81.09	42.4	39.0	325.0	447.8
10^{-1} molar	74.81	42.1	30.6	279.9	340.5
10^{-2} molar	85.50	55.0	42.8	411.0	436.9
10^{-3} molar	88.01	50.1	38.8	364.3	421.9

TABLE 6. GERMINATION AND EARLY GROWTH OF CORN IN REDISTILLED WATER AFTER SOAKING WITH VARIED CONCENTRATION OF MANGANESE CHLORIDE. THE LENGTH AND DRY WEIGHT OF SEEDLING WERE DETERMINED AT THE END OF THE EXPERIMENT (191 HOURS). TEMPERATURE CA. 18° C.

Seeds soaked with	Percentage germination after 50 hr.	Length (mm.) of seedlings (mean of 50)		Dry weight of 50 seedlings (mg.)	
		Root	Shoot	Root	Shoot
Control	43.37	45.1	40.8	379.1	505.3
10^{-1} molar	32.69	43.4	30.9	294.5	379.8
10^{-2} molar	58.46	65.6	47.0	415.0	515.6
10^{-3} molar	48.90	54.5	41.2	393.2	480.0

TABLE 7. GERMINATION AND EARLY GROWTH OF CORN IN REDISTILLED WATER AFTER SOAKING WITH VARIED CONCENTRATION OF MANGANESE NITRATE. THE LENGTH AND DRY WEIGHT OF SEEDLING WERE DETERMINED AT THE END OF THE EXPERIMENT (200 HOURS). TEMPERATURE CA. 14° C.

Medium	Percentage germination after 88 hr.	Length (mm.) of seedlings (mean of 50)		Dry weight of 50 seedlings (mg.)	
		Root	Shoot	Root	Shoot
Control	36.75	52.3	37.0	382.2	530.6
10^{-1} molar	28.66	37.3	35.5	312.4	465.5
.10^{-2} molar	44.00	68.5	42.1	495.8	604.4
10^{-3} molar	37.09	58.7	36.6	423.1	537.9

TABLE 8. THE INCREASE PERCENTAGE OF LENGTH AND DRY WEIGHT OF SEEDLINGS PRETREATED WITH 10^{-3} MOLAR MANGANESE SALT, CALCULATED TABLES 5, 6 AND 7.

Manganese salts	Increase percentage over control			
	Length of seedling		Dry weight of seedling	
	Root	Shoot	Root	Shoot
$MnSO_4$	29.7	9.7	26.4	2.4
$MnCl_2$	45.4	15.1	9.4	2.0
$Mn(NO_3)_2$	30 9	13.7	29.7	13.9

The data indicate that the germination was somewhat accelerated by the pretreatment with manganese salts of 10^{-2} and 10^{-3} molar concentration. Data on the length of seedlings are given in the third columns of tables 5, 6 and 7. It is evident from these tables that manganese salts in the concentration of 10^{-2} molar promoted the elongation of the root considerably, the increase amounting to 29.7% in the case of the sulphate, 45.4% in the case of the chloride and 30.9% in the case of the nitrate (table 8). The effect of manganese salts in lower concentration (10^{-3} molar) on the elongation of the shoot was, however, negligible.

The last two columns of tables 5, 6 and 7 gives the dry weight of root and shoot. The increase of dry weight as a result of pretreatment essentially paralleled increases in length, the shoots showing little or no response, while the roots appeared to be increased in dry weight as a result of pretreatment.

DISCUSSION

The data presented above show that either the immersion of seeds in or the pretreatment of seeds with the solutions of manganese sulphate, chloride or nitrate results in promotion of growth. Under the present experimental conditions, the presence of manganese salts in appropriate concentration increases the percentage of germination, the amount of dry substance and the elongation of shoot and root. These findings are in agreement with those of Loo (6).

The fact that various manganese salts affect the growth of corn plants in a similar manner suggests that the growth promotion effect is probably due to the action of the cation itself.

Miss Brenchley (2 and 3) found manganese to be toxic if present in too high a concentration, but she also found that smaller quantities appeared to cause a general stimulation of plant growth. Concentration of manganese sulphate above 1:100,000 were injurious to barley. McCool (8) found manganese sulphate in the concentration of 15 parts per million to be injurious to the field pea, while 30 parts per million prevented the root growth entirely. In the present experiments, however, the favorable concentration of manganese salts for germination and early growth of corn plant were much greater than that used by the above-mentioned investigators.

SUMMARY

The immersion of corn seeds in solution of manganese sulphate, manganese chloride or manganese nitrate of various concentrations increased the percentage of germination and promoted the early growth of corn seeds and seedlings, the most effective concentration being 10^{-3} molar. Pretreatment of corn seeds with solution of manganese salts before germination also resulted in growth promotion.

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FLOWERING PLANTS OF NORTHWESTERN CHINA, I.

CHIEN P'EI

During the years from 1940 to 1945, four explorations were undertaken by different institutions to northwestern China. The National Institute of Geography made two explorations to Sinkiang and to Kansu-Tsinghai border. In these two explorations, the main purpose of which was of course to make geographical surveys, about 600 numbers of flowering plants were collected from Sinkiang and 700 from the Kansu-Tsinghai border. The third exploration was undertaken by the Institute of Zoology and Botany, Academia Sinica, to the border of Kansu and Tsinghai. This collection of flowering plants was small and majority of the specimens were without notes and numbers of the collector. The fourth collection was made within the Kansu Province, especially in mountainous regions of Kilien-shan, Hsiolung-shan and Min-shan, under the direction of the Forest Utilization Survey of the Kansu Provincial Government. It secured about 700 numbers of flowering plants.

All these collections are now deposited in the Institute of Botany, Academia Sinica. Although they may not represent a thorough exploration of flowering plants of these provinces, yet they have aroused the interest of the writer to make a preliminary study. As the information of flowering plants of these regions has been rather meager, I hope this preliminary report will be of help to those who are interested in the plant distribution of these regions.

A short description for each species and tentative keys for certain genera are given. For the convenience of comparing ecological variations of certain species, some of the plants occurring in other provinces of northern China are occasionally cited and discussed in this paper.

SALICACEAE

Two genera, *Populus* and *Salix,* of this family are widely distributed in China. In our herbarium, most of the specimens of the genus *Salix* have been poorly collected and majority of them are sterile. So this genus is not considered in the present paper.

POPULUS Linnaeus

Usually tall trees with bark smooth and fissured; buds usually viscid or not viscid, often tomentose, ovoid to elongated cylindric; branchlets terete or slightly ridged to conspicuously angled, with or without pubescence; leaves very variable, ovate to broad-ovate, ovate-elliptic to oblong, sinuate to deeply lobed, usually with incurved glandular teeth, translucent margin present in certain species, tomentum on lower surface of leaves either persistent or deciduous, leaves on long shoot, on short branchlet and on the sucker are all different; glands 2, conspicuous, present or absent, on the upper surface at the base of leaf-blade; petioles compressed or terete; inflorescence a catkin, usually appearing before leaves, male catkin earlier than female ones; subtending bract usually laciniate, often tomentose; disk usually persistent, cup-shaped or saucer-shaped; stamens ranging from a few up to 60 in number, usually scarlet-red; ovary enclosed at the lower part by a cup-shaped disk, with 2-4 stigma; matured fruit a

capsule, opening into 2-4 valves; seeds very small, surrounded by silky hairs, ovoid or obovoid; cotyledons elliptic.

About 50 species widely distributed in temperate regions of Asia, Europe, America and Africa. About 25 species in China.

1. Bark smooth .... 2.
1. Bark rough or fissured .... 4.
2. Leaves tomentose beneath; petiole terete .... *P. alba.*
2. Leaves glabrous, more or less glaucous beneath; petiole compressed .... 3.
3. Bark white; leaves shallowly serrulate .... *P. tremula* var. *Davidiana.*
3. Bark greenish gray; leaves grossly serrate .... *P. hopeiensis.*
4. Leaves chartaceous; leaf-margin not translucent .... 5.
4. Leaves usually leathery; leaf-margin distinctly translucent .... *P. pyramidalis.*
5. Branchlets terete .... *P. cathayana.*
5. Branchlets angled .... 6.
6. Leaves ovate or ovate-or elliptic-oblong, pubescent or densely pubescent on veins .... 7.
6. Leaves usually rhomboid, glabrous .... *P. Simonii.*
7. Leaves large, up to 13 cm. long, ovate and subcordate, densely pubescent on veins of both surfaces; petioles long up to 10 cm. long, compressed .... *P. szechuanica.*
7. Leaves smaller, about 10 cm. long, ovate to rhombic-ovate or elliptic-oblong, pubescent on veins beneath; petioles short, 4 cm. long, terete .... *P. laurifolia.*

POPULUS ALBA Linn. Sp. Pl. 1034. 1753.

Tomentum persistent on buds, branchlets, underside of leaves and petioles when matured; branchlets terete; leaves broadly ovate, ovate-oblong to ovate-orbicular, usually deeply and palmately lobed on long branchlets, unlobed on first grown leaves, acute at apex, truncate or subcordate at base, 5-10 cm. long, 5-10 cm. broad, usually with 5 basal nerves, lateral veinlets pinnate.

Sinkiang: T'a-cheng, *C. Lin 74,* "Cultivated", Vernacular-name: Tsing-yang.

Kansu-Tsinghai border: without precise locality, *Y. C. Wu; T. J. Chow 365.*

Populus alba Linn. has been reported in many parts of Northern China. It is not readily distinguished from *Populus tomentosa* Carr., owing to the presence, in both species, of tomentum on the lower surface of leaves when young. In *Populus alba* Linn. the tomentum is persistent on the lower surface of leaves, and the stipules are longer and linear in shape, being 1.5 cm. in length.

POPULUS TREMULA Linn. var. DAVIDIANA Schneid., Sargent's Pl. Wilson. 3: 24. 1916.

Populus venusta David, Jour. Trois, Voy. Chin. 1: 294. 1875.

Populus tremula Fr., Nouv. Arch. Mus. Paris, ser. 2, 7: 94 (Pl. David. 1: 284). 1884.

Branchlets terete, glabrous, grayish or light chestnut-brown; buds ovoid, small, about 2 mm. long, slightly viscid; leaves broadly ovate, rounded, sometimes much broader than long, sinuate-serrate, 2.5-4.5 cm. long, 3-4.5 cm. broad, leaves on the sucker up to 15 cm. long, usually trinerved at base, acute at apex, rounded at base or slightly cordate, glabrous, slightly glaucescent beneath; petioles compressed, 1.5-3.5 cm. long.

Liaoning: Hsiungyüe, *Y. Yabe,* Aug. 13, 1910.

Sinkiang: Chenghua, Chuot'ou-ho, *C. Lin 303.* Yümin, Hsint'iho-kou, *C. Lin 133.*

Kansu: Hinglung-shan, *C. K. Chow,* Aug. 1942. *Hsiolung-shan, C. H. Hê,* June-Aug. 1945.

Distrib.: Also in Amur and Ussuri regions, Korea, Hokkaido, and very common from Honan and Shansi southward to the Hupeh, Szechuan and Yunnan provinces.

The southern form of this variety may be identical with the Himalayan species, *Populus rotundifolia* Griff., which usually has leaves orbicular and not so variable as in typical *Populus tremula* Linn. var. *Davidiana* Schneid. The Liaoning plants have the leaves on sucker varying from orbicular to ovate, while the specimens from southern provinces of China have more constant orbicular leaves.

POPULUS HOPEIENSIS Hu and Chow, Chow Familiar Trees Hopei, 56. 1934.

Branchlets terete, grayish, glabrous, newly grown branchlets chestnut-brown, pubescent; buds small, ovoid, nearly rounded, viscid, tomentose, tomentum somewhat deciduous; leaves firm, ovate-oblong to elliptic-oblong or suborbicular, sometimes reniform, acute at apex, broadly cuneate at base, margin sinuate-serrate with 4 to 6 incurved teeth, 3-5 cm. long, 2-5 cm. broad, glabrous or with a few scattered hairs on veins and leaf-margin, more or less glaucescent beneath, no glands at base of the leaf-blade; petioles compressed, 2-4 cm. long.

Hopei: Tang-shan, *Y. Yabe*, May 8, 1907.

This species is reported from the Hopei province only. Chow stated that Mr. Rehder of Arnold Arboretum suggested it to be a hybrid between *Populus tomentosa* Carr. and *Populus tremula* Linn. var. *Davidiana* Schneid., resembling *Populus canescens* Sm. of Europe, which is a hybrid between *Populus alba* Linn. and *Populus tremula* Linn. It seems to me that this species may be a form of *Populus tremula* Linn. var. *Davidiana* Schneid, from which it differs by its leaf characters only. Cytological and genetical studies are needed to prove this.

POPULUS CATHAYANA Rehd., Jour. Arn. Arb. 12: 59. 1931.

Populus suaveolens Schneid, Sargent's Pl. Wilson. 3: 18 and 28. 1916, quoad specimina sinensia citata. Rehd., Jour. Arn. Arb. 4: 138. 1923, pro parte; Man. Cult. Trees and Shrubs. 88. 1927, pro parte. Henry, Gard. Chron ser. 3, 53: 198, fig. 88. 1913, quoad icon. and pro parte; Elwes and Henry, Trees Gr. Brit. and Irel. 7: 1841, t. 410, fig 25, 1913, quoad icon. Non Fischer.

Populus szechuanica Schneid., Sargent's Pl. Wilson. 3: 21. 1916, quoad specimina Wilsoniana citata, nos. 1413, 2165, 4346, 4348 and 4361.

Branchlets terete, yellowish-gray, glabrous, or pubescent on newly grown branchlets; buds elongated, viscid, ciliated on scale-margin, about 1 cm. long; stipules triangular, mucronate, about 2 mm. long; leaves usually ovate, chartaceous, serrulate, densely pubescent on the margin, shortly acuminate at apex, symmetrically or asymmetrically rounded at base, densely pubescent on the upper surface of the basal part of the leaf-blade, the remaining portion of the blade glabrous, green above, paler beneath, 6-11 cm. long, 3-5 cm. broad, up to 13 cm. long on vigorous shoot, basal glands usually absent; petioles slightly compressed, pubescent, 2-6.5 cm. long; fruiting catkin about 6.5 cm. long; fruit opening into 3-4 valves, tip of valves reflexed.

Shansi: Wutai-shan, Taihusi-cheng, *Y. Yabe*, July 20, 1907.

Kansu: Kilien-shan, *C. K. Chow 54* and *84*, July-Aug. 1945; Tow-ho, *C. K. Chow*, July 1944; Peilung-kiang, *C. K. Chow*, July 1944.

For a long time, the Chinese plants with above described characters have been called *Populus suaveolens* Fischer. After examining the Fischer's type specimen in Leningrad in 1928, Rehder found out that he had misidentified all the Chinese plants as *Populus suaveolens* Fischer, and he pointed out the differences between *Populus*

suaveolens Fischer and his species, *Populus cathayana*. *Populus cathayana* Rehd. is not a variable species especially on leaf characters, and it is very much similar to *Populus suaveolens* Fischer which has shorter petiole and depressed veinlets on the upper surface of leaves. Rehder stated that there is no *Populus suaveolens* Fischer in China, but this statement should be reserved until all the bordering provinces of China are thoroughly explored.

POPULUS SZECHUANICA Schneid. var. ROCKII Rehd. and Kobuski, Jour. Arn. Arb. 13: 386. 1932.

Branchlets terete, yellowish and slightly villose when young, grayish when mature, on vigorous shoots purplish-brown; buds viscid, ovoid, acute, ciliated on scales; leaves ovate, 8-13.5 cm. long, 7-12 cm. broad, acute or shortly acuminate at apex, subcordate at base, veins densely pubescent on both surfaces or slightly pubescent, margin minutely glandular serrate and ciliate; petioles compressed, 5.5-10.5 cm. long, slightly villose.

Kansu: Hsiolung-shan, *C. H. Hê B.* and *C.*, June-Aug. 1945.

This variety differs from the typical form in its densely pilose veins on the lower surface of leaves, and in having smaller leaves. These characters may be due to the change of environment. With the scanty material at hand, I cannot say whether the plant from southern Kansu is the same as that of Szechuan.

POPULUS LAURIFOLIA Ledeb. Fl. Alt. 4: 297. 1833. Schneid., Sargent's Pl. Wilson. 3: 35. 1916.

Populus balsamifera Linn. var. *laurifolia* Wesmael, DC. Prodr. 16(2): 330. 1868. Burkill, Jour. Linn. Soc. Bot. 26: 535. 1899,? pro parte.

Populus sp. Hers, Jour. N. China Br. R. As. Soc. 53: 113. 1922.

Branchlets yellowish-gray; long shoot usually angled; buds viscid; stipules small, triangular, about 2 mm. long, glabrous on long shoots, pubescent on short and fruiting shoots; leaves ovate, ovate-elliptic, broader below the middle, chartaceous, minutely dentate-serrulate, broadly cuneate, rounded to subcordate at base, shortly acuminate at apex, 6-10 cm. long, 3-6 cm. broad, those on the long shoots glabrous above and pubescent on veins beneath, those on fruiting shoots pubescent on both surfaces; petioles terete, sparsely to densely pubescent, 1.5-3.5 cm. long; fruiting catkin about 6 cm. long, densely pubescent on rachis; fruit opening into 2-3 valves; valves reflexed, pubescent outside; disk persistent, pubescent outside.

Liaoning: Kungchu-ling, *Y. Yabe,* Aug. 1, 1910.

Sinkiang: T'a-cheng, *C. Lin 75,* "cultivated", vernacular-name: Ye-yang. Ho-feng, Saili-shan, Sungshu-kou, *C. Lin 188.*

Distrib.: From Altai Mts. southward to the provinces Hopei and Honan.

The specimens from Sinkiang agree exactly with the characters described by Ledebour, but that from Liaoning does not agree so well with Ledebour's description. I think the characters of the Liaoning plant may possibly be variations due to a change of environmental conditions. *Populus laurifolia* Ledeb. is distinguished from other species of this genus by its angled branchlets, by its leaves broader below the middle and by the pubescent rachis of its catkin.

POPULUS SIMONII Carr., Rev. Hort. 360. 1867. Rehd., Jour. Arn. Arb. 12: 63. 1931.

Populus suaveolens Fisch. var. *a* Maxim., Bull. Soc. Nat. Moscou, 54: 51. 1879.

Populus Przewalskii Maxim., Mel. Biol. 11: 321. 1881; Bull. Acad. Sci. St. Petersb. 27: 540. 1882.

Populus balsamifera μ. *Simonii* Wesmael, Bull. Soc. Bot. Belg. 26: 378. 1887. Burkill, Jour. Linn. Soc. Bot. 26: 536. 1899.

Populus balsamifera var. *laurifolia* Burkill, Jour. Linn. Soc. Bot. 26: 535. 1899, pro parte, non Wesmael.

Populus balsamifera var. *suaveolens* Burkill, Jour. Linn. Soc. Bot. 26: 535. 1889, non Loudon.

Populus brevifolia Carr. ex Schneid., Ill. Handb. Laubholzk. 1: 16. 1904.

Populus suaveolens var. *a. angustifolia* Gombocz, Math. Termesz. Közl. 30: 110 (Monog. Gen. Populi). 1908, vix Regel.

Populus Przewalskii f. *microphylla* Gombocz, Math. Termesz. Közl. 30: 105. (Monog. Gen. Populi). 1908.

Populus suaveolens Schneid., Sargent's Pl. Wilson. 3: 18. 1916, pro parte, quoad specimina citata, Tibet, Kansu, Chili et Wilson nos. 2162 and 4577 e Szechuan bor. Rehd., Jour. Arn. Arb. 4: 135. 1923, non Fischer.

Populus suaveolens var. *Przewalskii* Schneid., Sargent's Pl. Wilson. 3: 32. 1916, specimina e Mongolia citato et descriptione exceptis. Rehd., Jour. Arn. Arb. 4: 133. 1923.

Trees of medium height; branchlets slender, terete, grayish, glabrous; newly grown branchlets usually angled, reddish-brown, glabrous; buds elongated and pointed, viscid; leaves glabrous, when young densely puberulent on veins, rhombic-ovate to rhombic-elliptic, acuminate at apex, broadly cuneate or subrounded at base, serrulate or crenate-serrulate or entire, bright green above, paler beneath, 3-9 cm. long, 2-4 cm. broad, the first grown leaves usually smaller; petioles 1-3.5 cm. long, reddish, terete; stipules linear-filamentous, membranaceous, brown, about 1.5 cm. long, glabrous; fruiting catkin slender; capsule small, 2-valved; valves about 5 mm. in length.

Shantung: Tsinan-fu, Lung-shan, on slopes, *C. Y. Chiao 3127,* Sept. 18, 1930, "Tree 22 feet high". Tai-shan, *H. Migo,* April 24, 1942.

Hopei: Laiyuan-hsien, Chienkan-ho, alt. 1500 m., *K. M. Liou 2427,* May 14, 1934, vernacular-name: Shan-tsing-yang.

Chahar: Kalgan, without collections, cultivated, "Leaves obovate, bark smooth".

Kansu: Kilien-shan, *C. K. Chow 88* and *111,* July-Aug. 1945.

Distrib.: Also in Honan and Shansi southward to the provinces along the Yangtze River and also in Manchuria and Korea.

The leaf characters of this species are very constant, but a few botanists basing on minor variations of leaves proposed to separate them into forms. This species is easily recognized by its small leaves, angled branchlets and small capsules.

POPULUS PYRAMIDALIS Salisb. Prod. 395. 1796. Roz. ex Lam. Encyc. 5: 235. 1804.

Populus nigra Linn. var. *italica* Du Roi, Harbk. Baumz. 2: 141. 1772.

Populus nigra Linn. var. *sinensis* Carr., Rev. Hort. 340. 1867.

? *Populus acuta* David, Jour. Trois. Voy. Chin. 1: 294. 1875. Bretschneider, Hist. Eur. Bot. Disc. China, 851. 1898.

A tall tree, usually with ascending branches; bark furrowed; buds ovoid or subrounded, viscid; leaves variable in size, leathery, usually rhombic-ovate, acuminate, grossly serrate, 4-10 cm. long, 3.5-9 cm. broad, margin distinctly translucent; petioles strongly compressed.

Kansu: Kilien-shan, *C. K. Chow 7.*

Sinkiang: T'a-cheng, *C. Lin 73,* cultivated.

Distrib.: Cultivated everywhere in China, and also in Europe and Western Asia.

The specimens cited above are sterile. H. F. Chow said that this species, when in bloom, has only male catkins. It is very distinctive from other species in the genus *Populus* by the ascending habit of its branches resulting in the columnar form of the tree, and by its leathery leaves with translucent leaf-margin which is very characteristic.

ZYGOPHYLLACEAE

Low shrubs or undershrubs, with articulate branches; leaves opposite or alternate by suppression, with small stipules, simple, 2-foliolate to pinnately compound; flower hermaphrodite, regular, rarely irregular, white or yellow to blue or red, single in axils of leaves or branchlets, in terminal racemes or cymose panicle; sepals 5, rarely 4, free, inserted at the base outside the disk, imbricate, rarely valvate; disk convex or depressed; stamens equal to or 2-3-times as many as the petals, inserted at the base of the disk, filaments usually with a scale at the base or at middle; anther versatile, longitudinally dehiscent; ovary sessile, angled or winged, 2-12 celled, cells rarely with a transverse septa, narrowing into a terminal style; stigma usually simple, rarely 5; ovules 2-many; fruit coriaceous or corneous, 2-10, free or united, often spiny cocci, or dehiscent capsules; seeds albuminous or exalbuminous.

25 genera with about 180 species chiefly in arid regions of both hemispheres. In China, 5 genera have been reported. Only 3 genera are found among our specimens.

1. Fruit a capsule or dividing cocci; leaves from 2-foliolate to pinnately compound or laciniate......2.
1. Fruit a drupe; leaves simple, fleshy, usually alternate ....*Nitraria.*
2. Leaves opposite, 2-foliolate to pinnately compound; fruit 4-5-cornered or winged, indehiscent or dehiscent into 4-5 cocci ....*Zygophyllum.*
2. Leaves alternate, irregularly multifid; fruit a many-seeded capsule or a berry ... .*Peganum.*

ZYGOPHYLLUM Linnaeus

Low shrubs or prostrate perennial herbs; leaves opposite, 2-foliolate to pinnately compound in several jugates, rarely simple, fleshy; stipules 2, membranaceous, each often united at the base with the corresponding one on the opposite leaf; flowers white, pinkish or yellow, with red or purple spots at base of petals, solitary or in pairs, terminal or nestling among the stipules; calyx 4-5-parted, persistent or deciduous, imbricate; petals 4-5, clawed, imbricate, contorted; disk fleshy, angled, cup-shaped or concave; stamens 8-10, inserted to the base of the disk, longer than petals, filaments filiform, with a scale at base; anthers oblong; ovary sessile, 4-5-cornered, 4-5 rarely 2-3-celled, tapering into an angular style; ovules 2-many in each cell; fruit 4-5-cornered or winged, indehiscent or dehiscent into 5 cocci, or loculicidally 5-valved, the endocarp sometimes loosening; seeds solitary or many in each cell, pendulous, albumen scanty.

About 60 species distributed in South Africa and Australia; 6 species recorded in north and northwestern China.

1. Low shrubs; leaves with 2-leaflets....................................*Z. xanthoxylum.*
1. Perennial herbs; leaves 2-3-jugates.................................... 2.
2. Leaflets obovate, obtuse....................................*Z. Loczyi.*
2. Leaflets linear-oblong, mucronate....................................*Z. mucronatum.*

ZYGOPHYLLUM XANTHOXYLUM Maxim. Fl. Tangut. 103. 1889.

Sarcozygium xanthoxylum Bunge, Linnaea, 17: 8, t. 1. 1843.

Shrubs with yellowish-gray bark; leaves fleshy with 2-leaflets, opposite or whorled at base of branchlets; leaflets linear, spathulate, entire, obtuse, greenish, 1.5-2 cm. long, 2-4 mm. broad; stipule uniting with the corresponding one on the opposite leaf to form an ovate structure, with entire, white, membranaceous; flowers single or few nestling among the whorled leaves; pedicel 1 cm. long; fruit straw-colored, with persistent style, broadly 3-winged, 2.5×2 cm. including wings; seed solitary.

Kansu: Kilien-shan, *C. K. Chow 168,* July-Aug. 1945, fruit.

Kansu-Tsinghai border: *T. J. Chow 306.*

Distrib.: Also in Mongolia and Sinkiang.

It is a common weed growing on drier soil in northwestern China. It differs from the other two species by its woody habit and by its 2-foliolate leaves.

ZYGOPHYLLUM LOCZYI Kanitz. Pl. Exped. Szechenyi in As. Centr. Lect. 13. 1891.

Perennial herbs, with many grooved branches at base, branching dichotomously; leaves fleshy, 2-jugate; rachis winged; stipule united at base with the corresponding one on the opposite leaf, membranaceous, with irregularly undulate margin; leaflets obliquely obovate, obovate-oblong, entire, obtuse, 1-1.5 cm. long. 5-9 mm. broad; flower single or two in axils of the dichotomous branches; capsule cylindric, 2 cm. long, slightly winged.

Kansu-Tsinghai border: *T. J. Chow 277* and *298.*

This species is much similar to *Zygophyllum Potanini* Maxim. from which it differs by its grooved stems and sylindric capsule which is not broadly winged.

ZYGOPHYLLUM MUCRONATUM Maxim., Bull. Acad. Sci. St. Peterb. 27: 438. (Mel. Biol. 9: 175). 1881.

Perennial herbs, dichotomously branched, slightly pubescent while young; leaves 2-jugate, fleshy; rachis winged; stipules 2, each united at base with the corresponding one on the opposite leaf, white, membranaceous, ovate-lanceolate, margin fimbriate; leaflets linear, linear-oblong, entire, mucronate at apex, 8-12 mm. long, 2-3 mm. broad; flowers usually 2, at axils of branches, pinkish; pedicel about 5 mm. long; sepals elliptic-oblong, 5 mm. long; petals unequal in length, obovate, 5-7 mm. long; stamens 10, unequal, shorter than petals; scales on filaments truncate and unequally toothed; ovary oblong; capsules ovoid while young, 5-angled.

Kansu: Kilien-shan, *C. K. Chow 128,* July-Aug. 1945. Hsiolung-shan, *C. H. Hê,* 1945.

The characters of our specimens agree quite well with the original diagnosis of this species. Although in the original description the leaves were described as 3-jugate, the photograph of the type specimen shows that they are 2-jugate. The numerical "3" in the original diagnosis may be a misprint. This species is easily distinguished from other Chinese species by its 5-angled capsules, small mucronate leaflets and pinkish flowers.

PEGANUM Linnaeus

Perennial pungent herbs or undershrubs; stems usually grooved; subglabrous to densely pubescent and glandular; leaves alternate, laciniate from the base, glabrous or pubescent; stipules bristle-like; flowers large, solitary, white; sepals usually 5, rarely 4,

linear, simple or 2-3-fid to laciniate, persistent; petals usually 5, rarely 4, inserted on base of the disk; stamens usually 15, inserted with the petals, with filaments dilated at base; ovary 3-celled or rarely 2, on the thick cupulate disk; ovules many in each cell; style simple, clavate-trigonous at apex, sometimes spirally twisted; capsule subglobose, 3-lobed, 3-celled, many seeded; seeds angulate-reniform, albuminous.

About 4 species in temperate Old World, 2 of them have been recorded in China.

1. Stems woody, densely pubescent and glandular; leaves pubescent; flowers small, petals 1.2 cm. in length, sepals usually trifid to laciniate . . . . *P. nigellastrum.*
1. Stem herbaceous, not densely pubescent; leaves glabrous or slightly pubescent; flowers large, petals up to 2.7 cm. in length, sepals usually simple, occasionally 2-3-fid or pinnatifid . . . . *P. harmala.*

PEGANUM NIGELLASTRUM Bunge, Mem. Acad. Sci. St. Petersb. Sav. Etrang. 2: 87 (Enum. Pl. Chin. Bor.). 1832.

Pungent undershrubs; stems grooved, densely pubescent and glandular; leaves irregularly multifid, pubescent and glandulose, lobes linear; stipules obsolete; flowers solitary, axillary, white; sepals usually trifid to pinnatifid, as long as the petals; petals oblong, 1.2 cm. in length; capsule globose, shorter than sepals; seeds curved, angular and compressed.

Hopei: Nankow, without collector. Peiping, *F. T. Wang 20217,* 1929.

Chahar: Kalgan, *C. R. Reeves,* Summer 1921.

Inner Mongolia: Barun Sunit, steppes, sandy soil, *G. Roerich 35* and *52,* June 7 to 8, 1935. The Old City, 23 miles NE. of Tumur Hada, sandy and stony steppes, *Y. L. Keng 3228* (*573*), July 31, 1935, "Flowers white, 3-lobed capsules".

Distrib.: Also in Kansu.

This species differs from *Peganum harmala* Linn. essentially in more compact form, much shorter leaves, denser pubescence, and presence of glands which densely cover the whole plant and make it pungent. The herbaceous habit of *Peganum harmala* Linn. and the woody habit of *Peganum nigellastrum* Bunge are poor characters for distinguishing species, because in both species the aboveground parts die in winter. This species is of rare occurrence in northwestern China.

PEGANUM HARMALA Linn. Sp. Pl. 444. 1753.

Perennial herbs, with strong and deep tap-root, aboveground parts usually herbaceous; stems grooved, up to 40 cm. tall, pubescent or sparsely pubescent; leaves irregularly multifid, lobes linear, glabrous or slightly pubescent, acute to apiculate at apex; flowers large, solitary, axillary; peduncle usually 1.5 cm. long; sepals linear, simple or occasionally 2-3-fid or slightly laciniate, much longer than petals, up to 2.7 cm. in length; petals oblong, 1.5 cm. in length; fruit 1.2 cm. in diameter.

Hopei: Without precise locality, *C. F. Li 10642,* 1929.

Kansu: Plain of Hohsi, *C. K. Chow 159,* July-Aug. 1945.

Kansu-Tsinghai border: *T. J. Chow 201, 234, 245* and *296.*

Sinkiang: Wusu, Hsiotsa'o-hu, *C. Lin 49* and *50.*

Distrib.: This species occurs also in Shansi and in Europe.

NITRARIA Linnaeus

Deciduous shrubs with spiny branchlets; bark smooth, whitish or yellowish-gray; leaves fleshy, linear spathulate or obovate, entire or rarely dentate at apex, with subulate

caducous stipules; flowers small, yellowish-green in terminal loose circinate inflorescence; sepals 5, imbricate, connate at base, persistent; petals valvate, concave; stamens 10-15, without appendage; ovary 3-celled; stigmas 3; each cell with 1 ovule; drupe with thin exocarp and hard endocarp, 1-seeded by abortion.

4 species in Russia, Central Asia, Eastern Siberia and Northern Africa. Three species recorded in China.

1. Leaves linear spathulate; fruit small, usually about 5 mm. in length . . . . *N. Schoberi.*
1. Leaves obovate; fruit large, usually more than 1 cm. in length. . . . . *N. Roborowskii.*

NITRARIA SCHOBERI Linn. Sp. Pl. ed. 2. 638. 1762.

Shrubs with whitish or yellowish-gray bark, light yellowish while young, alternately branched, spinescent; branchlets densely pubescent while young; stipules small, less than 1 mm. in length, persistent, membranaceous, white, ovate to ovate-lanceolate; leaves fleshy, oblanceolate or narrowly obovate-oblong, spathulate, sessile, densely depressed pilose on both surfaces, obtuse at apex, gradually narrowed to the base, 8-25 mm. long, 4-5 mm. broad; inflorescence terminal, scorpioid, cymose or subumbellate, pubescent; flowers subsessile; calyx 5-lobed, lobes ovate, densely pubescent outside, persistent on fruit; petals white, spathulate, glabrous, about 4 mm. in length; anthers yellow; drupe black, minutely pitted at the base of the endocarp, about 6 mm. long.

Hopei: T'ang-kou, *C. Miao 36,* May 19, 1943. Peiping, *F. T. Wang 20313,* 1929.

Inner Mongolia: The Old City, sandy steppes near the Batu Halka River, *Y. L. Keng 3455 (803),* Aug. 11, 1935, "Leaf thick fleshy, fruit berry black, Mongolian-name: Harmuek, edible". Shara Muren, river terrace, sandy soil, *G. Roerich 202,* June 24, 1935, "Flowers white".

Shansi: Southern part, alt. 800 m., *T. Tang 726,* May 9, 1929, "Shrub 4 feet, 1-2 inches in diameter, bark yellowish-gray, flowers white".

Kansu: Kilien-shan, *C. K. Chow 165,* July-Aug. 1945.

Sinkiang: Wusu, Hsiotsa'o-hu, *C. Lin 54,* "Vernacular-name: Peh-t'zu". Ngê-min, Chin-ch'ang, *C. Lin 163.*

Kansu-Tsinghai border: *T. J. Chow 279, 285, 295* and *304.*

Distrib.: Also in Syria, Turkestan and Mongolia, and also reported from western Szechuan.

This species differs from the related species by its linear spathulate leaves and by the minute pits on the endocarp of the fruit. Komarov separates this species into several varieties based on the shape and color of the fruit. Our plant should belong to his variety *sibirica* Pall. (Fl. Ross. 1: 79, tab. 50A. 1784).

NITRARIA ROBOROWSKII Komarov, Act. Hort. Petrop. 29: 169. 1908.

Deciduous shrub up to 2 meters high; bark white or yellowish-gray, brownish-white when young; branchlets with spines, glabrous; leaves fleshy, alternate, rarely opposite, ovate, ovate-oblong, oblong spathulate, shortly petioled, glabrous, villose when young, entire, minutely apiculate at apex, rarely dentate at apex, cuneate or broadly cuneate at base, 1-2 cm. long, 5-10 mm. broad; inflorescence lax with few flowers; drupe shortly pediceled, narrowly ovoid; seeds about 1 cm. long, 4 mm. in diameter; pits few, larger than in other species.

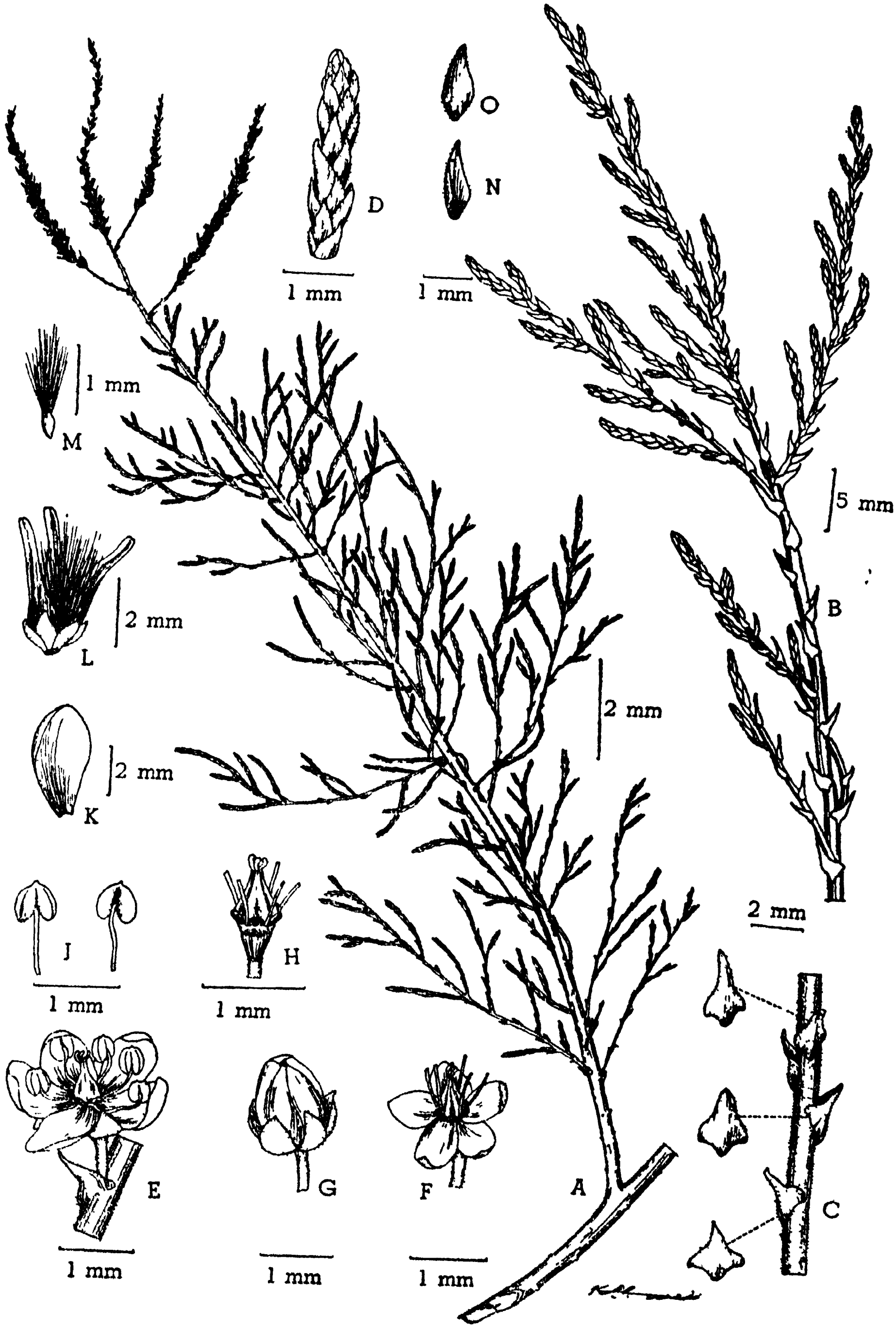

Fig. 1. Tamarix hispida Willd. A. Branch with inflorescence, B. Branch enlarged, C. A portion of branch enlarged, D. Tip of branchlet enlarged, E. Flower with subtending

Sinkiang: Ching-ho, Yen-ch'i, *C. Lin 383* and *386.*
Kansu: Kilien-shan, *C. K. Chow,* July-Aug. 1945.
Kansu-Tsinghai border: *T. J. Chow 309.*
Distrib.: Also in Afghanistan.

This species may be differentiated from other species of this genus by its large ovate, ovate-oblong and oblong spathulate leaves and large fruit with a few large sized pits.

TAMARICACEAE

TAMARIX HISPIDA Willd., Act. Acad. berol. 77. 1812-'13. Fig. 1.

Densely pubescent and glaucous small trees; branchlets reddish-brown, branching freely; leaves scale-like, sessile, ovate to ovate-lanceolate, about 1.5 mm. long, obtuse or acute; subtending bracts nearly deltoid; inflorescence in terminal panicle; flowers small; sepals densely pubescent outside, ovate; petals oblong, glabrous, about 4 mm. long; disk 5-lobed; stamens 5, inserted between the disk-lobes.

Sinkiang: Wusu, Hsiotsa'o-hu, *C. Lin 47,* "Vernacular-name: Red-willow".
Distrib.: Also in Central Asia.

This species is a new record to Sinkiang. It differs from other species of this genus by its densely pubescent and glaucous habit.

WINTER CONDITIONS OF WOODY PLANTS IN WEI BASIN

C. K. CHOW

The present paper contributes a knowledge of the winter conditions of deciduous trees and shrubs commonly found on the loess plain in Wei Valley embracing central Shensi and eastern Kansu. It includes 81 species and 9 varieties. The main features used for identification are the characters of buds, leaf scars, bud scales, scale scars, stipule scars, lenticels and pith; the presence or absence of spur shoots, spines, thorns, prickles, glaucous bloom, or pubescence; the color, taste and odor of the twigs; and also the form of the plant, the nature of the bark, and others. All materials were collected by the writer and drawings were made at the time of collection. The numbers on the drawings correspond to the number of species arranged in the text.

KEY TO SPECIES

This key is arranged in artificial system, and applicable only to the Wei Basin.

1. Leaf scars alternate 2
1. Leaf scars opposite 67
2. Terminal buds present 3
2. Terminal buds wanting 37
3. Terminal buds inconspicuous or rudimentary 4
3. Terminal buds conspicuous 8
4. Strong growing vines, climbing by tendrils .... 59. *Vitis vinifera*
4. Shrubs or trees, without tendrils 5
5. Shrubs, usually with arched stems and prickles 6
5. Trees, with erect, distinct trunk and without prickles 7

6. Twigs purplish red, glabrous, glaucous ....25. *Rubus coreanus*
6. Twigs grayish brown, tomentose, not glaucous ....26. *Rubus parvifolius*
7. Bud scales glabrous ....71. *Diospyros Lotus*
7. Bud scales pubescent ....72. *Diospyros Kaki*
8. Buds naked ....12. *Pterocarya stenoptera*
8. Buds covered by scales 9
9. Buds covered by a single scale ....18. *Magnolia denudata*
9. Buds covered by 2 or more scales 10
10. Stems climbing ....61. *Parthenocissus tricuspidata*
10. Stems erect (including shrubs and trees) 11
11. Buds resinous 12
11. Buds not resinous 17
12. Twigs angled 13
12. Twigs not angled 14
13. Twigs often smooth, reddish brown; pith light brown; buds covered by 6-7 scales; stipule scars nearly triangular ....2. *Populus Simonii*
13. Twigs usually grooved, light greenish yellow; pith white green; buds covered by 3-4 scales; stipule scars falcate ....3. *Populus cathayana*
14. Twigs and bud scales usually pubescent or tomentose ....4. *Populus tomentosa*
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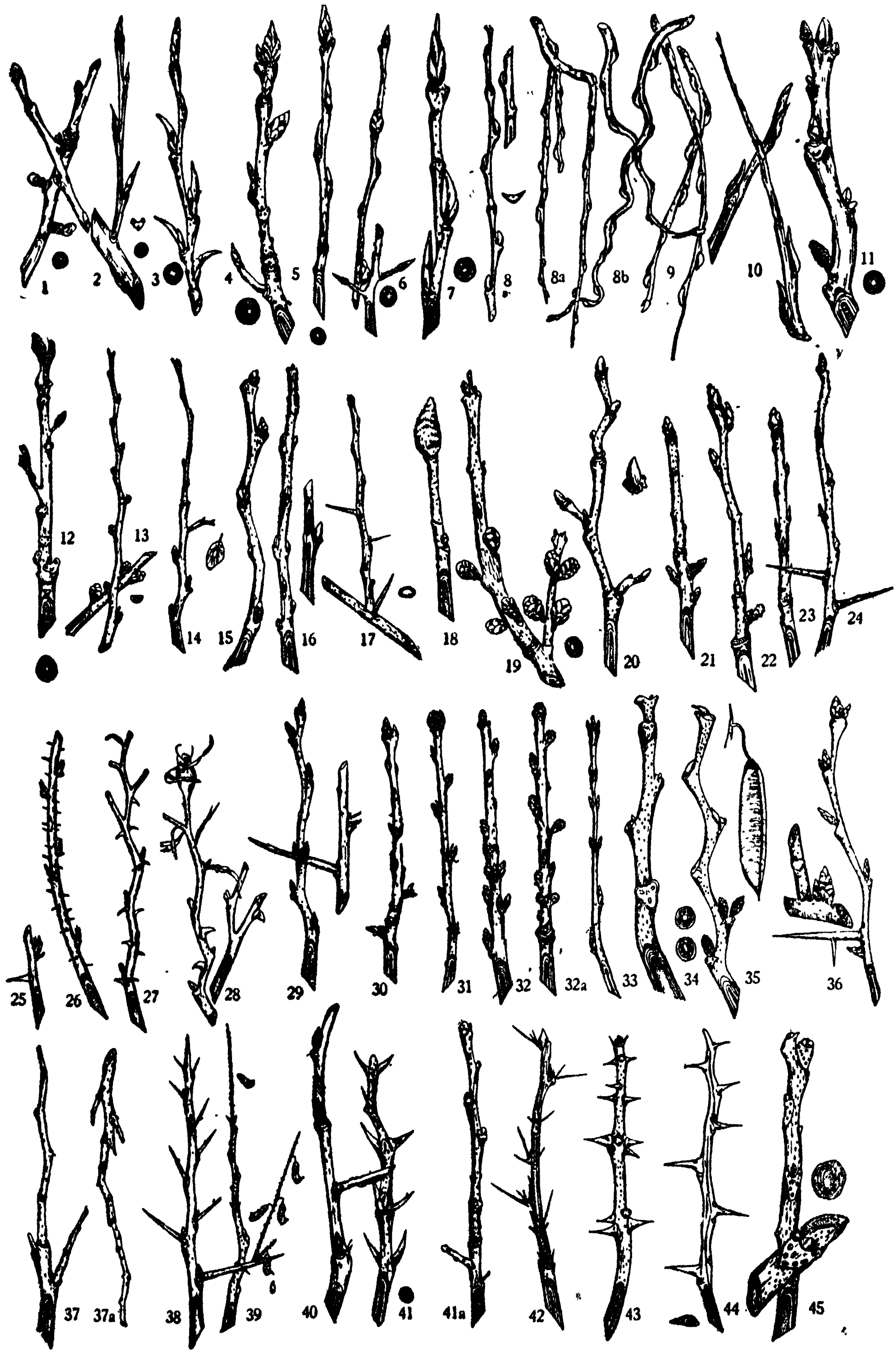
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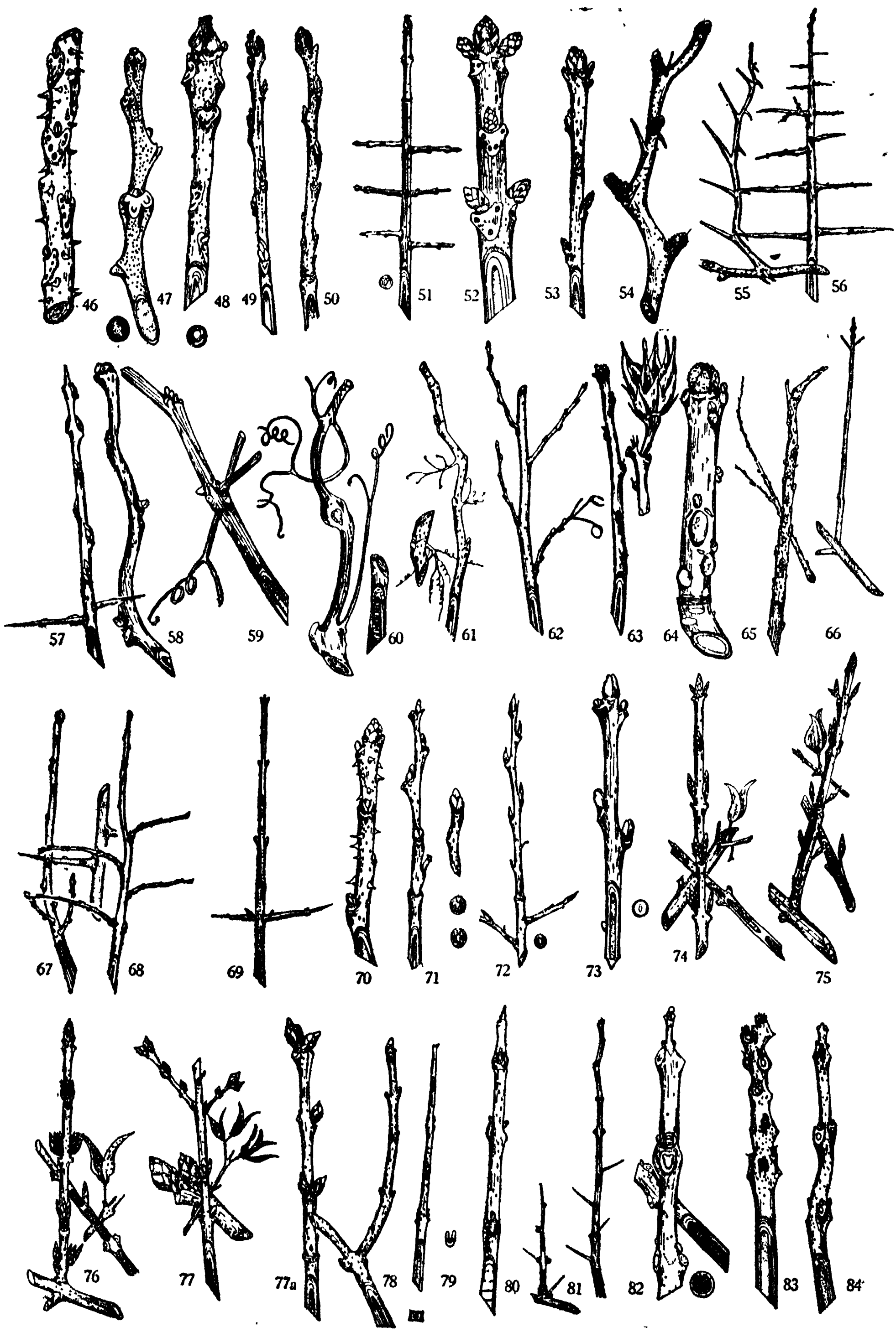
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1. GINKGO BILOBA L. Tree up to 25 m. high, with a broadly ovoid or pyramidal crown. Bark gray or ashy brown, somewhat rough, often divided by longitudinal furrows into irregular or nearly square, scaly plates. Twigs aromatic, with pale or yellowish brown and glabrous shoots, and blackish spurs densely covered with leaf scars; pith yellow, triangular in cross-section; lenticels scarce, gray, large, but inconspicuous on young twigs. Terminal buds short conical, obtuse, 4 mm. long, covered with 4 greenish brown or purplish yellow, asperate scales; lateral buds smaller, present only on the long shoots. Leaf scars alternate, triangular or lunate, brown, with gray hairs at upper margin; bundle scars 2, prominent, round, gray, at the center of leaf scar; stipule scar absent; scale scars conspicuous.

2. POPULUS SIMONII Carr. Tree up to 15 m. tall, often with a narrowly ovoid head. Bark smooth, greenish gray or cream-colored when young; roughened, deeply furrowed at base of trunk. Twigs slender, angled, glabrous, reddish brown; pith light brown, stellate in cross-section; lenticels sparse, elliptical, brown. Terminal buds conical, 1 cm. long, covered by 6-7 purplish brown, glabrous, slightly resinous scales; lateral buds similar. Leaf scars alternate, U-shaped, brown in color; bundle scars 3, round, brown, arranged along upper side of leaf scars; stipule scars pale, nearly triangular; scale scars conspicuous.

3. P. CATHAYANA Rehd. Tree reaching 20 m. high, with an ovoid or globose head. Bark similar to that of *P. Simonii*. Twigs angled when young, light greenish yellow, glabrous, lustrous, and grooved; pith small, white-green, stellate in cross-section; lenticels scarce, round, gray. Terminal buds conical, 1.5 cm. long, covered by 3-4, glabrous, red or purplish brown, resinous scales; lateral buds similar, but smaller and divergent; leaf buds slender, flower buds stout. Leaf scars alternate, triangular, grayish yellow; bundle scars 3, round, ashy yellow, arranged along upper margin of leaf scar; stipule scars falcate; scale scars ring-like.

4. P. TOMENTOSA Carr. Tree up to 20 m. high, with a broad ovoid or conical crown. Bark on young trees smooth, ashy blue or greenish white, with distinct, black, large lenticels; in age becoming blackish and breaking up into deeply furrows separated by thin, irregular flakes. Twigs moderately stout, smooth, tomentose, light blue when young, later becoming blue-gray or cream-colored; pith light yellow, stellate in transverse section; lenticels sparse, gray or brown. Terminal buds conical, 1.2 cm. long, covered with 10-15, reddish purple, resinous, slightly tomentose, imbricate scales; lateral buds ovoid, acute, 1-4 mm. long, covered with more than 4 scales. Leaf scars alternate, blue-gray, semicircular or reniform, with 3, gray, tumid, bundle scars; stipule scars linear; scale scars annular.

5. P. PYRAMIDALIS Borkh. Tree up to 25 m. high, with a narrow columnar crown. Bark similar to that of *P. Simonii*. Twigs glabrous, shiny, light yellow when young and later becoming greenish white; pith white, stellate in transverse section; lenticels sparse, dot-like, gray. Terminal buds conical, acuminate, 1.3 cm. long, covered with 8, greenish tawny, glabrous, resinous, imbricate scales; lateral buds solitary, 8-10 mm. long, covered with 3-4 scales. Leaf scars alternate, triangular, light yellow, with 3, circular, brown bundle scars; stipule scars black; scale scars annular.

6. P. TREMULA L. var. DAVIDIANA Schneid. Tree up to 10 m. tall, with a conic-ovoid crown. Bark smooth, greenish white to cream-colored, dark gray or black at

base of old tree, sometimes with nearly square, scaly plates divided by fissures. Twigs slender, slightly zigzag, glabrate, lustrous, yellowish brown when young, eventually becoming brown or greenish gray; pith brown, stellate in cross-section; lenticels scarce, dot-like. Terminal buds conical, about 5 mm. long; lateral buds solitary, appressed; leaf buds acute, compressed ovoid, slightly resinous, covered with 5, red or purplish brown, glabrous, imbricate scales; flower buds similar, but larger. Leaf scars alternate, triangular, grayish brown, with 3 gray, concave bundle scars, stipule scars lineate; scale scars annular.

7. P. PURDOMII Rehd. Tree to 20 m. tall, with an ovoid crown. Bark greenish white or blue-gray, usually deeply furrowed, divided by brownish gray, moderately thin flakes at base of trunk. Twigs stout, glabrous, lustrous, greenish- or yellowish-brown; pith light brown, stellate in transverse section; lenticels scarce, linear and gray in color. Terminal buds acute conical, 2 cm. long, covered by 7 reddish yellow, glabrous, slightly resinous, imbricate scales; lateral buds appressed, solitary, flattened-conical, covered with 3 scales. Leaf scars alternate, deltoid, brown, with 3, rounded, brown bundle scars, near upper margin of leaf scars; stipule scars and scale scars all conspicuous.

8. SALIX MATSUDANA Koidz. Tree up to 20 m. tall, with a broad, ovoid crown. Bark greenish brown and smooth when young, becoming blackish roughened by thick, rectangular or irregular scaly ridges separated by longitudinally deep furrows; inner bark brown. Twigs slender, slightly zigzag, glabrous, lustrous, pubescent when young and light brownish or yellowish green; pith small, white to light green, circular in cross-section; lenticels sparse, round or elliptical, pale brown. Terminal buds wanting; lateral buds simple, appressed, ovoid, obtuse, curved, 6 mm. long, covered by a single, brown, glabrous or pubescent scale. Leaf scars alternate, deltoid or crescentric, grayish yellow, with 3 dark yellow bundle scars, arranged along the upper margin of the leaf scar; stipule scars minute, round; scale scars distinct.

a. var. PENDULA Schneid. This variety differs from the typical species in having pendulous and longer branchlets.

b. var. TORTUOSA Vilm. This variety differs from the typical species in having tortuous branchlets.

9. S. BABYLONICA L. Tree up to 15 m. high, often with pendulous brts. and ovoid crown. Bark blackish, divided by deep, longitudinal fissures into thick, interlacing, scaly ridges. Twigs slender, reddish brown, lustrous, glabrous or slightly pubescent; pith small, white. Lenticels, buds, leaf scars, etc., similar to those of *S. Matsudana,* but the lateral buds acute, and the scale slightly pubescent.

10. S. PURPUREA L. var. STIPULARIS Franch. Bushy shrub to 2-3 m. tall. Bark grayish brown, with slightly longitudinal fissures at base of trunk. Twigs smooth, tough, glabrous, lustrous, light greenish brown. Terminal buds wanting; lateral buds solitary, long ovoid-conical, acute, 1 cm. long, covered by a single, purple, glabrous scale; stipule scars gray, tumid, dot-like. The lenticels, leaf scars and bundle scars, similar to those of *S. Matsudana.*

11. JUGLANS REGIA L. Rounded or ovoid headed tree, up to 15 m. high. Bark silvery, often breaking up into rectangular, scaly plates with deep, black, longitudinal furrows in between. Twigs stout, glabrous or slightly pubescent, purplish or grayish

brown; pith lamellate, stellate or triangular in cross-section; lenticels sparse, dot-like. Terminal buds conical, about 9 mm. long, covered with 2-3 valvate, tomentose, bronze scales; lateral buds similar, but smaller and with more scales; flower buds usually larger, covered with numerous, imbricate, pubescent scales. Leaf scars alternate, U-shaped or nearly triangular, grayish brown; bundle scars 3, C-shaped, each at a corner of the leaf scar; stipule scar absent; scale scars lineate.

12. PTEROCARYA STENOPTERA DC. Tree up to 15 m. tall, with obovoid crown. Bark gray to grayish brown, often broken up into irregular scaly plates separated by deep furrows. Twigs grayish brown, glabrous or villose; pith chambered, light brown; lenticels narrowly elliptical, pale or brown in color. Buds dark brown, naked, stalked, tomentose; terminal ones large and erect; lateral ones simple or superposed, 2 cm. or more above the leaf scar; flower buds elliptical. Leaf scars alternate, triangular or cordate, tumid, brownish gray; bundle scars 3, U-shaped, raised, dark brown, each at a corner of the leaf scar; stipule scar wanting.

13. ULMUS PUMILA L. Tree reaching 20 m. high, often with an obovoid crown. Bark gray to dark gray, rough, often divided by deep furrows into nearly rectangular, flat-topped ridges; inner bark brown. Twigs slender, tough, zigzag, bluish gray or grayish green, glabrous or pubescent when young; pith small, white; lenticels round, yellow-brown. Terminal buds lacking; lateral buds small, solitary or superposed, ovoid, covered by several brownish red, imbricate scales which are pubescent at margin; flower buds similar, but subglobose and larger. Leaf scars alternate, very small, semicircular, brown, with 3 depressed bundle scars; stipule scars and scale scars indistinct.

14. U. PARVIFOLIA Jacq. Tree up to 15 m. tall, with dense, slender brts. and usually ovoid crown. Bark bluish gray, with numerous, conspicuous, large, tumid lenticels, usually breaking up into irregular, thin, flaky plates, white to yellow beneath. Twigs slender, tough, zigzag, dark brown, pubescent when young; pith small, white; lenticels dot-like, oblate, brownish yellow. Terminal buds wanting; lateral buds appressed, simple or collateral, ovoid, slightly flattened at apex, covered with 10 or more dark brown, imbricate scales. Leaf scars alternate, circular, white, turgid; bundle scars 3, slightly concave, dark gray, arranged in a line in the middle of leaf scar; stipule scars lineate, scale scars annular. Fruit often attached to the ends of brts. throughout the winter.

15. MORUS ALBA L. Tree up to 15 m. high, with ovoid or ellipsoid crown. Bark pale when young; in age becoming gray to dark brown, divided by deep furrows into thick scaly plates. Twigs with milky juice, tough, yellowish gray to brown, glabrous or pubescent at first; pith white, round; lenticels numerous, tumid, yellow-brown. Terminal buds wanting; lateral buds solitary, sometimes superposed, spherical-ovoid, with acute apex, 1.5 mm. long, covered with 5-6 thin, yellowish purple, imbricate scales. Leaf scars alternate, semicicular, triangular or deltoid, projected; bundle scars numerous, highly tumid, arranged in an elliptical circle; stipule scars lunate, slightly depressed; scale scars conspicuous.

16. BROUSSONETIA PAPYRIFERA Vent. Tree reaching 10 m. high, with an irregular umbrella-shaped or ovoid crown. Bark dark brown when young, becoming yellowish white, occasionally with shallow longitudinal fissures, in which numerous orange lenticels

are present. Twigs rough, greenish gray to blackish, tomentose, with milky juice; pith spongy, white, very large; lenticels numerous, yellowish brown. Terminal buds absent; lateral buds solitary, ovoid, obtuse, covered with 2-3 valvate, slightly pubescent, grayish black to brown scales. Leaf scars alternate, sometimes opposite near the end of twig, deltoid, semicicular, pale; bundle scars 7-8, white, arranged in an elliptical circle or scattered in the center of the leaf scars; stipule scars linear; scale scars distinct.

17. Vanieria tricuspidata Hu. Thorny shrub to small tree, up to 8 m. high. Bark grayish brown, with shallow irregular fissures on young trees, often with thin scaly plates on old trunk. Twigs with milky juice, greenish gray to dark brown, somewhat zigzag, grooved, glabrous, sometimes pubescent on young twigs; pith small, white; lenticels numerous, linear to oblong, gray or grayish yellow. Terminal buds present; lateral buds solitary or collateral, accessory buds usually developing into thorns, and the true lateral buds twigs, covered with 4-5 glabrous, purple-brown scales. Leaf scars alternate, triangular or semicircular, brown; bundle scars numerous, white, usually arranged in an elliptical circle in the middle of leaf scar; stipule scars absent; scale scars indistinct.

18. Magnolia denudata Desrouss. Small tree up to 10 m. tall, with an obovoid crown. Bark gray, smooth, with shallow fissures, often brown up into irregular, small, scaly, exfoliating plates on the base of the trunk. Twigs yellowish green, shiny and glabrous; pith white; lenticels minute, elliptical, reddish brown. Terminal buds usually large, acute, 1 cm. or more long, covered by a single, grayish green, thick scale with dense, compact, yellow, silky hairs; lateral buds similar, but smaller. Leaf scars alternate, lunate, grayish brown; bundle scars 8 round, arranged in the center of the leaf scar; stipule scars lineate, encircling the twig; scale scars conspicuous.

19. Chimonanthus praecox Rehd. & Wils. Shrub up to 3 m. tall, with a round or obovoid head. Bark dark gray, smooth or with shallow furrows; inner bark aromatic. Twigs pubescent, brittle, green or greenish gray; pith white, nearly polygonal in cross-section; lenticels sparse, elliptic, brown. Terminal buds lacking; lateral buds usually solitary; leaf buds about 1 mm. long, covered with 2 pairs of gray-brown, pubescent scales, often appearing near the end of the twig; flower buds conspicuous, larger, obovoid, stalked, 1 cm. long, covered with 15 yellowish brown, pubescent scales. Leaf scars opposite, reniform, greenish yellow; bundle scars numerous, white, arranged along the margin of leaf scar; stipule scars absent; scale scars conspicuous.

20. Platanus orientalis L. Tree up to 25 m. high, usually with a broad-ovoid crown. Bark greenish white, usually with large, irregular, exfoliating flakes. Twigs somewhat zigzag, with grayish stellate hairs when young, light yellowish green to reddish brown, sometimes with spur shoots; pith light yellow; lenticels conspicuous, numerous, dot-like and white. Terminal buds lacking; lateral buds simple, divergent, resinous, conical, 5 mm. long, tortuous at apex, with a caplike, purplish red, glabrous scale. Leaf scars alternate, annular, encircling the buds, yellow-brown, with 7-8 tumid and dark brown bundle scars; stipule scars and scale scars ring-like, encircling the twig.

21. Malus asiatica Nakai. Tree up to 10 m. high, usually with an ovoid crown. Bark grayish brown, slightly furrowed at base. Twigs dark purple, pubescent or tomentose at spur and young shoots; pith small, white; lenticels numerous, large,

elliptical, brown. Terminal buds long ovoid, covered with several imbricate, small, brown, pubescent scales; lateral buds minute. Leaf scars alternate, semicircular, with 3 bundle scars; stipule scars lineate; scale scars lunate.

22. M. PRUNIFOLIA Borkh. Small tree reaching 9 m. high, with an ovoid crown. Bark blue-gray, smooth, but with thin, brownish gray, rectangular, scaly plates on old trunk. Twigs purplish brown; pith white; lenticels sparse, round, yellowish brown. Terminal buds ovoid, 1 cm. long; lateral buds smaller, covered with several acute-ovate, imbricate, pubescent scales. Leaf scars alternate, U-shaped, yellow to dark brown; bundle scars 3, round, slightly concave; stipule scars and scale scars distinct.

23. PYRUS SEROTINA Rehd. Tree up to 10 m. high, often with an ovoid crown. Bark brown to black, separated by deep furrows into irregular or narrow, scaly plates. Twigs with spur shoots, zigzag, slightly angled, lustrous, glabrous or villous, light yellow while young, dark-brown to purple the 2nd year; pith indistinct; lenticels numerous, oblong and pale. Terminal buds ovoid, 1 cm. long; lateral buds ovoid, smaller, acute, covered with 10 or more imbricate scales. Leaf scars alternate, deltoid, dark reddish brown; bundle scars 3, round, gray slightly depressed, arranged along the inner margin of the leaf scar; stipule scars indistinct; scale scars ring-like, conspicuous.

24. P. BETULAEFOLIA Bge. Tree to 10 m. tall, with ovoid crown; thorny brts. and dark reddish brown spur shoots. Bark blackish to grayish brown, often breaking up into rectangular or irregular scaly plates separated by longitudinal furrows. Twigs purple-brown, lustrous, tomentose during the first; pith very small, white; lenticels numerous, spindle-shaped and grayish white. Terminal buds 5 mm. long; lateral buds rather small, flattened-conic, covered with 6-7 tomentose, chestnut, imbricate scales. Leaf scars alternate, lunate, dark reddish brown, pubescent at rims; bundle scars 3, round, gray; stipule scars indistinct; scale scars conspicuous.

25. RUBUS COREANUS Miq. Shrub, with arched brs. to 4-5 m. long. Bark dark red, smooth. Twigs purplish red, smooth, glaucous, with stout, sharp prickles, 8 mm. long; pith spongy, large, slightly yellow; lenticels indistinct. Terminal buds rudimentary; lateral buds simple, slender, ovoid, 7 mm. long, with 4, light purple, glaucous scales with pubescent apex. Leaf scars alternate, semicircular to orbicular, gray; petioles usually persistent; stipule scars and scale scars indistinct.

26. R. PARVIFOLIUS L. Shrub, with very low, arched stems to 2-3 m. long. Bark grayish brown, rarely fissured on stems. Twigs tomentose, with numerous slender prickles, about 1 mm. long, and flattened at base; pith large, light brown; lenticels numerous, black, dot-like. Terminal buds inconspicuous; lateral buds long ovoid, 4 mm. long, covered with 4 brown, pubescent scales. Leaf scars alternate, lunate, petioles sometimes persistent; bundle scars indistinct; stipules occasionally persistent; scale scars distinct.

27. ROSA MULTIFLORA Thunb. Vigorous shrub, with reclining brs. to 2-3 m. long. Twigs light green, dark purple on sunny aspects, smooth to rough, slightly zigzag, with numerous, acute, hooked prickles which are gray, 5 mm. long, and often appearing in pairs below the leaf scars; pith large, white; lenticels dark gray, elliptical. Terminal buds large, conical; lateral buds simple or collateral, rather small, subglobose, covered with 2 pairs of serrate, dark, glabrous scales. Leaf scars alternate, triangular or lunate,

light yellow; bundle scars 3, white, each at a corner of the leaf scar; stipule scars absent; scale scars conspicuous.

28. R. CHINENSIS Jacq. Shrub to 2 m. tall, with low, upright stems and spreading brs. Bark grayish green to dark purple, sometimes with shallow fissures. Twigs dark purple to green, smooth, glabrous, zigzag, with yellowish brown, stout, hooked, 7 mm. long prickles. Terminal buds present; lateral buds solitary or collateral, conic, often covered with 2-3 pairs of glabrous, imbricate scales. Pith, lenticels and leaf scars, similar to those of *R. multiflora.*

29. PRUNUS ARMENIACA L. Ovoid to round-headed tree, reaching 10 m. high, with numerous, thorny brts. when young. Bark red to dark purple, in age breaking up into plates separated by fissures. Twigs light yellowish or purplish red, glabrous lustrous; pith very small, white; lenticels sparse, round, gray, indistinct at young twigs. Terminal buds wanting; lateral buds usually collateral; leaf buds ovoid-conical, 4 mm. long, with 8 pairs of scales which are imbricate, dark brown, glabrous, sometimes pubescent at margin; flower buds similar, but larger, at both sides of leaf buds. Leaf scars alternate, triangular or semicircular, black, tumid; bundle scars 3, black; stipule scars indistinct; scale scars conspicuous.

30. P. SALICINA Lindl. Small tree up to 8 m. tall, often with an irregular or ovoid crown. Bark blackish, lustrous, with irregular, revolute plates separated by shallow furrows. Twigs light yellow to dark red, smooth and glabrous; pith small, light green; lenticels numerous, minute, white. Terminal buds present, often with several accessory buds at the end of spur shoot; lateral buds ovoid-conical; leaf buds above the leaf scars, covered with 4-5 compact, imbricate, yellow, glabrous scales; flower buds similar, but larger, on both sides of the lateral buds. Leaf scars alternate, very small, semiorbicular, gray; bundle scar 1, gray, tumid, in the center of leaf scar; stipule scars very small; scale scars conspicuous.

31. P. TRILOBA Lindl. Shrub to small tree up to 3 m. tall, with a dense, spreading brs. and round head. Bark dark purple, lustrous, with a few revolute flakes. Twigs dark reddish brown, pubescent to tomentose; pith light red, shiny; lenticels sparse, gray, orbicular to elliptical. Terminal buds often with several accessory buds, clustered at the end of spur shoot; lateral buds often with 2-7 accessory buds; flower buds ovoid, 3 mm. long, covered with 4 pairs of dark brown scales with gray hairy margin. Leaf scars alternate, triangular, brown, with 3 minute, brown bundle scars; stipule lineate, persistent, scale scars conspicuous; scales often persistent until the second year.

32. P. PERSICA Stokes. Small tree up to 6 m. high, with an ovoid crown. Bark dark brown to brown-purple, smooth, with numerous horizontal, grayish white lenticels; on the base of trunk, usually breaking up into thin flakes. Twigs with spur shoots, light green, dark purple on sunny side, slightly angled, glabrous or pubescent when young, pith minute, white; lenticels numerous, very small, gray. Terminal buds present; lateral buds often collateral; leaf buds ovoid, 3 mm. long; flower buds oblong-ovoid, 5 mm. long, covered with 2-3 pairs of purple, pubescent, imbricate scales. Leaf scars alternate, small, prominent, gray, with 3 white bundle scars; stipule scars minute; scale scars distinct.

a. var. RUBRO-PLENA Schneid. Distinguished from the typical species by its tomentose bud scales.

33. P. DAVIDIANA Franch. This species differs from *P. persica* in having few or no spur shoots, acute ovoid flower buds and compressed conical leaf buds.

34. ALBIZZIA JULIBRISSIN Durazz. Tree reaching 15 m. high, with a broad spreading crown. Bark dark gray, smooth, with longitudinal furrows, and large, conspicuous lenticels. Twigs stout, grayish brown to yellowish green, lustrous, slightly angled, somewhat zigzag; pith lop-sided to round, white, greenish on margin; lenticels numerous, ovate to elliptical, grayish brown. Terminal buds wanting; lateral buds hemispherical, 1 mm. long, covered with 2 dark brown, tomentose scales, accessory bud present at the center of leaf scar, below the lateral bud. Leaf scars alternate, grayish brown, triangular, with 3 black, elliptical, projecting bundle scars; stipule scars conspicuous; scale scars indistinct. Fruit attached to the brt. throughout the winter.

35. CERCIS CHINENSIS Bge. Shrub to tree, reaching 15 m. high, often with an open, ovoid crown. Bark grayish brown, with numerous, horizontal, reddish brown lenticels; in age often breaking up into irregular, thin plates. Twigs grayish brown, glabrous, stout, zigzag, grooved when young; later becoming very rough; pith yellowish pink, shiny; lenticels round, variable in size. Terminal buds absent; lateral buds simple or collateral; leaf buds compressed ovoid, acute, about 3 mm. long, covered with 3-4 glabrous, dark red scales; flower buds ellipsoid, 8 mm. long, at either side of leaf buds, covered with numerous, ovate, imbricate scales. Leaf scars brown, alternate, triangular, semiorbicular or pentagonal; bundle scars 3, grayish white, each at a corner of the leaf scar; stipule scars and scale scars indistinct. Fruit often attached to the end of brt. throughout the winter.

36. GLLDITSIA SINENSIS Lam. Tree up to 15 m. high, with a spheroid crown. Thorns present, especially on large brs. near the trunk, reddish, stout, 15 to 30 cm. long, branched; pith reddish brown. Bark black, with numerous lenticels, becoming deeply furrowed in age. Twigs bronze to grayish green, brittle, zigzag, with swollen nodes; pith yellowish green. Terminal buds lacking; lateral buds conical, superposed, with 7-8 dark red, imbricate scales. Leaf scar alternate, semiorbicular or nearly triangular, grayish white, with 3 bundle scars; scale scars conspicuous. Fruit usually remaining the brs. throughout the winter.

37. SOPHORA JAPONICA L. Tree to 20 m. high, with a subglobose to ovoid crown. Bark blackish or black, rough, with rectangular, scaly plates separated by deeply longitudinal furrows. Twigs slightly bitter to the taste, glabrous, lustrous, pubescent when young, green or yellowish green on sunny side; pith yellowish green; lenticels distinct, elliptical to circular, grayish white. Terminal buds absent; lateral buds very small, submerged in the center of leaf scar, with several indistinct scales. Leaf scars alternate, small, hoof-shaped, grayish green, with 3 bundle scars; stipule scars and scale scars inconspicuous.

a. var. PENDULA Loud. Small tree to 5 m. tall, with twisting, spreading brs. and dense, curved pendulous brts. usually forming a umbrella-shaped crown.

38. S. VICIIFOLIA Hance. Shrub up to 2 m. tall, with spreading, thorny brs. Bark black to yellow brown, breaking up into thin, revolute flakes on the base of

stems; inner bark slightly yellow. Twigs grayish brown to brown, zigzag, lustrous, pubescent; pith white; lenticels yellowish brown. Terminal buds absent; lateral buds simple or collateral, 2 mm. long, covered with 4 grayish brown, pubescent scales. Leaf scars small, alternate, semiorbicular dark gray; bundle scars 2-3, gray; stipule linear, persistent; scale scars indistinct.

39. Amorpha fruticosa L. Shrub up to 5 m. tall, with an open, ovoid crown. Bark light bronze, with shallow furrows on the base of the stem. Twigs bronze, sparingly pilose, later becoming glabrate; pith white, very small; lenticels numerous, round, bronze in color. Terminal buds wanting; lateral buds globose, 1 mm. long, covered with 3-4, pubescent, gray-brown scales. Leaf scars alternate, semicircular, grayish brown, bundle scars 3, gray, arranged in a line. Stipules and scales persistent.

40. Wistaria sinensis Sweet. Tall climber with twisting stems to 8 m. long or more. Bark gray to dark brown, slightly rough. Twigs reddish yellow to gray, glabrous to pubescent; pith white, very small; lenticels numerous, spindle-shaped, grayish brown. Terminal buds wanting; lateral buds ovoid-lanceolate, 6 mm. long, covered with 3 reddish brown or yellowish brown scales which are glabrous to pubescent. Leaf scar alternate, semiorbicular to lunate, rather large, highly projected; bundle scars 3, bronze, arranged in a line; stipule scars linear, indistinct; scale scars conspicuous.

41. Robinia pseudoacacia L. Tree reaching 10 m. high, with an irregular, opened crown. Bark brown-gray to blackish, breaking up into longitudinal furrows and ridges. Twigs moderately stout, angled, somewhat zigzag, glabrous, reddish brown to dark gray; spines flattened triangular, about 1 to 4 cm. long, dark red to yellowish brown; pith lop-sided or elliptic, and white in color; lenticels orbicular, grayish or reddish brown. Terminal buds absent; lateral buds very small, naked and submerged beneath the leaf scar, usually superposed, covered with dense, brown, silky hairs. Leaf scars alternate, yellowish brown, rhomboidal to pentagonal, raised in the center; bundle scars 3, sickle-shaped. Fruit often attached to the brs. throughout the winter.

a. var. inermis DC. Small tree to 7 m. tall distinguished from R. pseudoacacia. by the small spinescent stipules.

42. Caragana chamlagu Lam. Bushy shrub to 1 m. tall. Bark blackish to bronze, coriaceous, smooth and shiny, breaking up into revolute flakes at the base of the stem. Twigs slender, tough, glabrate, angled, bronze to grayish brown; stipules usually spinescent, 1 cm. long; rachis persistent, spiny; pith very small, light green; lenticels numerous, small, elliptical, gray, usually arranged in lines. Terminal buds lacking; lateral buds appressed, compressed ovoid, 5 mm. long, covered with several erose, yellowish brown, glabrous scales. Leaf scars alternate, grayish brown, oblate, with 3 greenish bundle scars; scales usually persistent.

43. Zanthoxylum simulans Hance. Small tree up to 5 m. high, with a subglobose crown. Bark black, slightly roughened, with shallow longitudinal furrows. Twigs aromatic, dark green to purplish brown, glabrous or pubescent, at both sides of leaf scars, usually with 2-3 dark brown, stout, about 1 cm. long prickles; pith white; lenticels numerous, round or oblong, reddish brown or pale. Terminal buds subglobose, covered with 3, rough, brown, valvate scales; lateral buds similar, but smaller. Leaf scars

alternate, triangular or hoof-shaped, dark brown, with 3 pale bundle scars; stipule scars wanting; scale scars slightly conspicuous.

44. PONCIRUS TRIFOLIATA Raf. Bushy shrub, rarely small tree, reaching 4 m. high, with erect stems, numerous brs. and strong thorns. Bark green or grayish green, smooth, slightly fissured at base of stem. Twigs aromatic, thorny, stout, green, compressed, glabrous or slightly glaucous; pith large, light greenish white, triangular in cross-section; lenticels indistinct. Terminal buds wanting; lateral buds ovoid, less than 1 mm. long, present at the side above the thorns, covered with 2 valvate, reddish purple, glabrous scales. Leaf scars alternate, very small, semicircular, white, with 1 light green bundle scar; stipule scars and scale scars inconspicuous.

45. AILANTHUS ALTISSIMA Swingle. Tree up to 20 m. high, with an obovoid or conical crown. Bark pale to blackish, usually marked with conspicuous, large, spindle-shaped leaf scars, slightly rough, irregularly fissured at base of trunk. Twigs with exceedingly disagreeable odor, very stout, often more than 1 cm. in diameter, reddish or greenish brown, lustrous, pubescent to glabrous; pith large, white to red; lenticels numerous, fusoid or round, pale yellowish. Terminal buds absent; lateral buds simple, subglobose, covered with 2 triangular, reddish brown, pubescent, valvate scales. Leaf scars alternate, very large, cordate or hoof-shaped, gray to light green; bundle scars 7, arranged along the lower margin of leaf scars; stipule scars absent; scale scars inconspicuous. Fruit attached to the brts. during the winter.

46. A. VILMORINIANA Dode. Tree to 15 m. tall. Twigs pubescent and prickly when young, the prickles 3 mm. long, pale to dark brown, disappear on old trees. In other respects similar to *A. altissima.*

47. MELIA AZEDARACH L. Tree up to 10 m. tall, with a broad crown. Bark smooth dark brownish green while young, then dark brown and longitudinally furrowed. Twigs very stout, zigzag, greenish brown at sunny side and dark green at the shady side, hairy when young, then glabrous; pith white, polygonal or round; lenticels numerous, minute, round, white, rarely reddish brown. Terminal buds wanting, lateral buds solitary, globose, covered with 3 tawny-rusty, tomentose valvate scales. Leaf scar alternate, three-lobed, reddish brown, with 3, white, C-shaped bundle scars. Fruit hung at the end of brts. throughout the winter.

48. CEDRELA SINENSIS Juss. Ellipsoid headed tree up to 15 m. tall. Bark reddish brown or dark brown, grooved, wih exfoliating scaly plates. Twigs very stout, light greenish brown to grayish green, glabrate or pubescent; pith large, light green; lenticels numerous, oblong or elliptical, grayish brown. Terminal buds short conical, acute, 1 cm. long, covered with several valvate, pubescent, brown foliaceous scales; lateral buds smaller, solitary, ovoid, covered with 5, valvate, brown, pubescent scales. Leaf scars alternate, large, hoof-shaped, cordate, or triangular-semiorbicular, pale brownish; bundle scars 5, C-shaped or lunate; stipule scars lacking; scale scars conspicuous.

49. DISCOCLEIDION RUFESCENS Pax. & K. Hoffm. Shrub, rarely small tree, up to 2-3 m. tall. Bark smooth, dark purple, with numerous clefts at base. Twigs moderately stout, glabrous or silky, with strongly disagreeable odor; pith large, white; lenticels numerous, round, brown to gray, arranged in lines. Terminal buds ovoid, acute, curved at apex, covered by 3, dark gray or brown, silky, scales; lateral buds appressed, solitary, smaller,

acute, ovoid. Leaf scars alternate, triangular or semicircular, dark green, with 7 round, white bundle scars arranged in a semicircle; stipules and scales persistent.

50. PISTACIA CHINENSIS Bge. Tree to 15 m. high, often with wide-spreading, subglobose crown. Bark gray, smooth when young, in age breaking up into thin, irregular, scaly plates, yellow-brown underneath. Twigs slightly bitter to taste, slightly compressed, lustrous, pubescent, yellowish brown or gray-brown, slightly angled; pith large, white; lenticels numerous, round, pale or brown. Terminal buds conical, 5 mm. long, covered with 8 imbricate scales; lateral buds triangular-ovoid, 2 mm. long, covered by 4-5 valvate scales which are purple at apex and green at base. Leaf scars alternate, U-shaped or deltoid, light grayish yellow, with 3-4 dot-like bundle scars; stipule scars absent; scale scars lunate, gray.

51. EVONYMUS BUNGEANA Maxim. Shrub to small tree reaching 5 m. tall, with dense, pendulous brts. and an ovoid crown. Bark blackish, divided by narrow fissures into elongate plates. Twigs slender, usually 4-angled, glabrous, shiny, grayish green to purplish brown; pith white, fusiform in cross-section; lenticels scarce, dot-like, gray-brown. Terminal buds ovoid, lateral buds solitary, covered by 4-5, green or purplish brown, glabrous or pubescent scales. Leaf scars opposite, semiorbicular, white; bundle scars minute, C-shaped; stipule scars dot-like; scale scars distinct; 2 scales usually persistent at the base of twig, in which an undeveloped bud is hidden. Fruit usually attached to brts. throughout winter months.

52. AESCULUS CHINENSIS Bge. Tree up to 20 m. high, often with an ovoid crown. Bark bitter to the taste, dark gray, with irregular, thin, exfoliating flakes, becoming white to brown when the older flakes fall off. Twigs very stout, glabrate, dark gray or bluish gray; pith white, large, ovoid in cross-section; lenticels numerous, dot-like, gray, variable in size. Terminal buds conspicuous, large, conical, 4-angled, about 1.5 cm. long, covered with more than 10 closely imbricate, brown scales white at margin; lateral buds similar, but smaller, 2-angled, often covered by 12 scales. Leaf scars opposite, hoof-shape, concave at both sides like a saddle, light brown; bundle scars usually 3, brown; stipule scars lacking; scale scars lineate.

53. XANTHOCERAS SORBIFOLIA Bge. Shrub to small tree, often 4 m. tall, with an ovoid head. Bark blackish, usually with longitudinal, shallow fissures separated by irregular scaly exfoliating plates. Twigs grooved, glabrous, dark purplish brown; pith large, brown; lenticels numerous, grayish brown. Terminal buds hemispherical, obtuse, 5 mm. long, covered with 10 dark purplish brown, glabrous scales, but pubescent at rims; lateral buds smaller, triangular-or long-ovoid. Leaf scars alternate, semicircular, pale; bundle scars 3, round, brown; stipule scars wanting; scale scars conspicuous.

54. ZIZYPHUS JUJUBA Mill. Tree up to 10 m. high, with an open, ovoid crown. Bark grayish black on old trees, breaking up into irregular or nearly longitudinal, scaly plates. Twigs dark purple or black, zigzag, lustrous glabrous; spurs present, short, black, roughened by numerous, minute scars of brts., usually furnished at the base with a pair of strong spines; pith light brown; lenticels numerous, dot-like, gray to black. Terminal buds wanting; lateral buds hemispheric, 1 mm. long, covered with 4-6 thick, brownish black, rough, acute, slightly pubescent scales. Leaf scars alternate, minute,

deltoid, grayish brown; bundle scars 3, pale, arranged in a line; scars of fruit shoots or brts. elliptical, reddish brown; scale scars conspicuous.

55. Z. SPINOSUS Hu. Shrub, rarely small tree, reaching 5 m. high, with an open, irregular head. Bark smooth, lustrous, red to dark purple on young trees, in age breaking up into irregular plates, and becoming brownish black to black. Twigs smooth, glabrous, slender, zigzag, spiny, reddish brown; pith minute, indistinct. In other respects similar to *Z. jujuba.*

56. SAGLRETIA PYCNOPHYLLA Schneid. Shrub up to 2 m. with erect stem, horizontal and thorny brs. Bark dark purplish brown, slightly fissured on the old stem. Twigs thorny, opposite or nearly so, slender, roughened, slightly pubescent and dark purple; pith small, light green; lenticels numerous, minute, white. Terminal buds wanting; lateral buds tiny, less than 1 mm. long, covered with two valvate, glabrous, dark brown scales. Leaf scars opposite or nearly so, triangular or semicircular, grayish brown, with 1, pale bundle scar; stipule scars and scale scars indistinct.

57. RHAMNUS GLOBOSA Bge. Shrub up to 3 m. high, with horizontal, stoutly thorny brs. Bark dark gray, lustrous, without fissures. Twigs alternate, slender, grayish green, pubescent; pith white; lenticels dot-like, whitish. Terminal buds absent; lateral buds acute, ovoid, 5 mm. long, covered with 2-6, small, imbricate, yellowish brown scales. Leaf scars opposite or alternate, semicircular, pale brown; bundle scars 3, slightly concave, grayish white; stipule scars minute, dotted; scale scars indistinct.

58. HOVENIA DULCIS Thunb. Ovoid headed tree, reaching 10 m. high. Bark blackish, breaking up into elongate, grayish brown, scaly flakes separated by fissures. Twigs stout, zigzag, pubescent, and blackish when young, lustrous, and grayish or purplish the 2nd year; pith large, white; lenticels pale. Terminal buds wanting; lateral buds compressed ovoid, solitary or superposed, angled, 3 mm. long, covered by 2, valvate scales with brownish tomentum. Leaf scars alternate, triangular or U-shaped, brown, with 3, round, grayish brown bundle scars; shoot scars usually appearing above the lateral buds, large, brown, triangular, tumid at margin and concave in center wherein a ring of bundle scars is present; stipule scars dotted, scale scars distinct.

59. VITIS VINIFERA L. Strong growing vine, with climbing stems, reaching 10 m. or more long, with stout, dark brown branched tendrils. Bark dark brown, with thin, fibrous, elongate plates, yellow brown underneath. Twigs stout, slightly compressed, glabrous, yellowish to purplish brown, with numerous longitudinal, parallel, tumid lines; pith light tawny; lenticels sparse, dark purplish. Terminal buds rudimentary; lateral buds simple, short ovoid-conical, 4 mm. long, covered with 2 outer purplish brown, pubescent scales. Leaf scar alternate, triangular, tawny; bundle scars and scale scars indistinct; stipule scars triangular.

60. AMPELOPSIS BREVIPEDUNCULATA Koehne. Strong growing vine, reaching 10 m. or more long, climbing by long, branched, dark gray tendrils. Bark dark gray, breaking up into irregular, scaly plates separated by shallow furrows. Twigs stout, angled, zigzag, twisted, pilose, grayish brown, slightly compressed, swollen at nodes; pith slightly chambered, white; lenticels numerous, dot-like, brown. Terminal buds wanting; lateral buds minute, indistinct, submerged beneath the persistent petioles, covered by several appressed, grayish brown, glabrous scales. Leaf scars alternate, erose, nearly

cordate, reddish brown and highly projecting; bundle scars indistinct, about 10, arranged in a circle near the margin of the leaf scar; stipules scars lineate; scale scars inconspicuous.

61. PARTHENOCISSUS TRICUSPIDATA Planch. High climber to 5 m. or more long, with numerous, short, much-branched, tough tendrils ending in adhesive tips. Bark blackish to purplish brown, usually with irregular clefts divided by revolute, thin flakes; inner bark rusty brown. Twigs long, slender, grayish brown, silky; pith small, green; lenticels fusoid, ashy brown in color. Treminal buds short ovoid-conical; lateral buds solitary, 2 mm. long, with 4 dark purple scales. Leaf scars alternate, round, grayish brown, with 7-8 bundle scars; stipule scars linear, brown; scale scars inconspicuous.

62. GREWIA PARVIFLORA Bge. Bushy shrub up to 1 m. tall. Bark dark gray, wrinkled. Twigs slender, tough, grayish brown, pubescent to tomentose; pith small, white; lenticels numerous, dot-like, gray to brown. Terminal buds wanting; lateral buds appressed, minute, ovoid, covered with several narrow, acute, gray-brown, tomentose scales. Leaf scars alternate, very small, semicircular, grayish brown, with 1 brown bundle scar; stipule scars and scale scars inconspicuous.

63. HIBISCUS SYRIACUS L. Bushy shrub up to 4 m. tall. Bark greenish pale, slightly smooth. Twigs gray, villose or glabrous, with a few short spur shoots; pith small, and white; lenticels numerous, round. Terminal buds absent; lateral buds 3 mm. in diameter, covered by lf.-bases. Leaf scars alternate, triangular-semicircular, blue-gray, with 4 bundle scars; stipules often persistent, stipule scars round, convex. Fruit usually clustered on the end of brts. throughout the winter.

64. FIRMIANA SIMPLEX W. F. Wight. Tree to 15 m. tall, with a globose crown. Bark smooth, light yellowish green or grayish green. Twigs stout, green or yellow-green, glabrous, lustrous; pith large, white; lenticels very sparse, indistinct, round or elliptical, rusty-brown. Terminal buds subglobose, 1 cm. long. covered by 10 or more triangular purplish brown, tomentose scales; lateral buds smaller, ovoid, covered with 2-3, pubescent scales. Leaf scars alternate, circular, elliptical or ovate, brown, with 10 or more dot-like bundle scars; stipule scars sickle-shaped, lanceolate or linear; scale scars conspicuous.

65. TAMARIX CHINENSIS Lour. Shrub to small tree, reaching 8 m. high, with numerous, slender, drooping brts. and an ovoid crown. Bark grayish brown, with longitudinal, elongate plates. Twigs very slender, yellowish brown, with more or less scaly leaves falling with the lvs., main shoot brownish red to purple, glabrous, with densely tumid twig scars; pith very small, indistinct; lenticels numerous, round or elliptical, brownish red. Terminal buds absent; lateral buds simple or collateral, globose, or short ovoid, covered with 10 pairs of light yellow, glabrate, imbricate scales. Leaf scars alternate, minute, linear; bundle scars indistinct; stipule scars absent; scale scars conspicuous.

66. WIKSTROEMIA SHAMAEDAPHNE Meisn. Small shrub, up to 80 cm. tall. Bark gray brown to reddish brown, slightly wrinkled. Twigs slender, tough, tetragonal or 4-angled when young, reddish purple or purplish green; pith dark yellow, elliptical in transverse section; lenticels minute, scarce, round, very conspicuous on older twigs. Terminal buds wanting; lateral buds solitary, appressed, very small, flattened ovoid, less than 1 mm. long, covered by 4-5 dark purplish, silky scales. Leaf scars opposite, small,

hoof-shaped; bundle scars numerous, yellowish white; stipule scars and scale scars inconspicuous.

67. ELAEAGNUS UMBELLATA Thunb. Shrub, rarely small tree, up to 4 m. tall, with many stout thorns and erose, umbrella-like head. Bark usually smooth. Twigs slender, silvery brown, mostly with silvery or brown scales; pith round, light tawny; lenticels indistinct. Terminal buds ovoid, 4 mm. long; lateral buds small, covered with 3-4 soft, brown scales which are variable in size and covered with dense silvery or brown warts. Leaf scars alternate, very small, semicircular, light green, with 1, white, lunate bundle scar; stipule scar absent; scale scars inconspicuous.

68. LAGERSTROEMIA INDICA L. Shrub, rarely small tree, up to 3 m. tall, often with a rounded head. Bark grayish brown, with a few black exfoliating flakes. Twigs slender, glabrous, angular, grayish brown and brittle; pith small, light green; lenticels inconspicuous. Terminal buds wanting; lateral buds appressed, compressed, long ovoid, covered with numerous, glabrous, imbricate scales. Leaf scars alternate, V-shaped or semicircular, ciliate at the lower rim; bundle scar 1, lunate, yellow, concave; stipule scars linear; scale scars indistinct.

69. PUNICA GRANATUM L. Small tree reaching 6 m. high usually with thorny brts. and irregular ovoid crown. Bark grayish brown, with numerous, white, horizontal, conspicuous lenticels, in age shallowly longitudinally fissured. Twigs slender, tetragonal, glabrous, with thin, elongated plates; pith light green, minute, round or elliptical in cross-section; lenticels numerous, minute, dotted, pale or tawny, arranged in rows. Terminal buds wanting; lateral buds 1 mm. long, ovoid, covered with 4 reddish brown, glabrous, imbricate scales. Leaf scars opposite, 1 mm. long and 1.5 mm. broad, semicircular or nearly cordate, yellow, with 1, lunate, pale bundle scars; stipule scars absent; scale scars conspicuous.

70. ACANTHOPANAX RICINIFOLIUS Seem. Round headed tree, up to 15 m. high, with numerous, stout, brown, acute, triangular prickles at brs. or stem. Bark dark gray, usually breaking up into deep furrows at base of old trunk. Twigs brownish green, smooth, with numerous spur shoots; pith white; lenticels large, elliptical, and grayish brown. Terminal buds present; lateral buds simple, conical, covered with numerous, purplish brown scales. Leaf scars alternate, lunate, rarely triangular, pale; bundle scars 8-10, round, white, arranged in a line; stipule scar absent; scale scars ring-like, conspicuous.

71. DIOSPYROS LOTUS L. Tree reaching 15 m. high, with an ovoid or rounded head. Bark black, often breaking up into conspicuous flakes separated by deep furrows; inner bark rusty-brown. Twigs slender to stout, zigzag, light yellowish brown to ashy-brown, slightly pubescent; pith white to light yellow; lenticels numerous, elliptical or round, gray to rusty brown. Terminal buds rudimentary; lateral buds simple, long-ovoid, acute, covered with 2-3 glabrous, dark purplish scales. Leaf scars alternate, semicircular, light tawny to ashy brown; bundle scar 1, lunate; stipule scar wanting; scale scars distinct.

72. D. KAKI L. Tree up to 15 m. tall, usually with a bell-shaped or spherical crown. Bark on the base of trunk, black, breaking up into rectangular scaly plates separated by deep furrows, on the upper part of trunk brownish ashy, with thin erose exfoliating scales. Twigs slender to stout, slightly zigzag, pubescent, brown to grayish brown;

lenticels circular to elliptical, gray to brown, numerous at the base of young shoots. The character of buds and leaf scars are similar to that of *D. Lotus,* but lateral buds ovoid and covered with pubescent scales.

73. FRAXINUS CHINENSIS Roxb. Tree up to 10 m. high, with an ovate crown. Bark gray, smooth when young; breaking up into narrow, interlacing ridges separated by shallow furrows on old trunk. Twigs glabrous, tough, gray brown, subglobose in cross-section, compressed at nodes; pith white, oblong in cross-section; lenticels sparse, linear. Terminal buds compressed ovoid, covered with 2 pubescent, black-brown, valvate scales; lateral buds similar, but smaller, Leaf scars opposite, lunate, hoof-shaped or semiorbicular, grayish brown; bundle scars 7-8, dotted, gray; stipule scars linear, scale scars inconspicuous.

74. FORSYTHIA SUSPENSA Vahl. Shrub up to 3 m. tall, with spreading or arching brs. Bark grayish to yellowish brown, usually with densely conspicuous lenticels. Twigs brownish yellow, glabrous, tetragonal, 4-angled near the end; pith hollow, but solid at nodes; lenticels numerous, orbicular or fusiform, yellowish gray. Terminal buds present; lateral buds solitary, superposed or collateral, with 2-4 accessory buds compressed conical to ovoid, acute, stalked, about 3 mm. long, with 10-12 glabrous, ciliate, brownish yellow, imbricate scales; flower buds similar, but larger. Leaf scars opposite, reniform, light grayish yellow, highly projecting; bundle scars light, grayish yellow; stipule scars linear; scale scars triangular. Fruit attached to the twigs throughout the winter.

75. F. VIRIDISSIMA Lindl. Pith lamellate throughout, sometimes lacking at basal internodes of vigorous brts. In other respects similar to *F. suspensa.*

76. F. INTERMEDIA Zabel. Resembling *F. suspensa,* but pith usually solid at the nodes, lamellate, rarely wanting between the nodes.

77. SYRINGA OBLATA Lindl. Shrub to small tree, commonly reaching 4 m. tall. Bark blackish, yellowish brow, with tumid lenticels, rarely furrowed. Twigs purplish brown, glabrate to pubescent, slightly angled when young, with densely spotted, gray to yellowish brown lenticels; pith white, ovate in transverse section. Terminal buds lacking; lateral buds usually collateral, 4-angled, acuminate, covered with 6-10 reddish purple, imbricate scales. Leaf scars opposite, triangular or semiorbicular, light yellowish brown, highly projecting, concave at top, with several lunate, white, raised bundle scars; stipule scars wanting, often with persistent scales.

a. var AFFINIS Lingelsh. Similar to that of the typical species, but with moderately stout, light green-gray, glabrous twigs, and acute, compressed ovoid buds, covered by light greenish yellow scales.

78. PERIPLOCA SEPIUM Bge. Shrub, with upright, climbing, or twining stems, reaching 6 m. long. Bark with milky juice, yellowish brown, smooth, or grooved. Twigs slender, tough, glabrous, lustrous, reddish brown, often with shedding, scaly epidermis; pith round, green; lenticels, numerous, dotted, and yellowish brown. Terminal buds absent; lateral buds less than 1 mm. long, at center of leaf scar, covered with 2, very small, brown, pubescent, valvate scales. Leaf scar opposite, dark brown, highly projected (1-2 mm. high); bundle scars 1, semicircular, gray, slightly tumid; stipule scars lineate; scale scars indistinct.

79. Vitex negundo L. var. incisa Clarke. Bushy shrub to 2 m. tall. Bark gray, smooth. Twigs slender, tetragonal, 4-angled, glabrous or pubescent, light yellow-gray; pith tetragonal, white; lenticels numerous, dot-like white, variable in size. Terminal buds wanting; lateral buds superposed, very small, ovate, with several tomentose, indistinct scales. Leaf scars opposite, rarely whorled, U-shaped, broader at middle, blackish; bundle scars numerous, lunate; stipule scar absent; scale scars inconspicuous.

80. Clerodendron trichotomum Thunb. Erect shrub up to 2 m. or more tall. Bark grayish blue when young, pale and rough when old. Twigs with strong disagreeable odor, stout, compressed at nodes, hirsute near the ends; lenticels numerous, round to elliptical, brown. Terminal buds lacking; lateral buds superposed, conical, with 2-4 dark purple, pubescent, scales. Leaf scars large, opposite, elliptical or broadly obovate, brown, projected at margin; bundle scars 8, brownish gray, U-shaped in arrangement; stipule scar wanting; scale scars indistinct.

81. Lycium chinense Mill. Thorny shrub to 2 m. tall, with spreading or arching brs. Bark pale, usually breaking up into shallow, longitudinal clefts. Twigs slender, angled, gray to light yellow, and with numerous, globose spurs; pith very small, nearly triangular; lenticels indistinct. Terminal buds absent; lateral buds solitary or superposed, flattened globose, less than 1 mm. long, present at the end of spur or above leaf scars, covered with 3-4 yellowish pale, glabrous, imbricate scales. Leaf scars alternate, semicircular, gray, with 1, blackish, bundle scars; stipule scars and scale scars inconspicuous.

82. Paulownia tomentosa Steud. Tree, reaching 10 m. high, with a subglobose crown. Bark black-gray or grayish brown, with shallow fissures, often breaking up into thin, irregular, exfoliating plates on old trunk, yellowish brown underneath. Twigs very stout, pubescent, brown colored at sunny side, and greenish brown at the shady side, flattened at nodes; pith chambered, large, white, round to elliptical in cross-section; lenticels scarce, elliptical, gray, often numerous on the nodes. Terminal buds absent; lateral buds usually superposed, small, subglobose, covered with 3 pairs of valvate, dark brown and pubescent scales. Leaf scars opposite, large, oblate or ovoid, white to light brown, bundle scars numerous, of various shapes; stipule scars lacking, scale scars inconspicuous.

83. Catalpa ovata Don. Ovate headed tree, up to 15 m. high. Bark light yellowish gray or black-gray, with erose, thin, exfoliating plates. Twigs stout, with conspicuous nodes, grayish brown; pith large, white; lenticels dotted, numerous, highly projecting, pale to brown, variable in size. Terminal buds lacking; lateral buds rounded or oblate, 2 mm. long, raised above the mid leaf scars, with 7-9, overlapping brown, pubescent scales which are slightly recurved, acute and ligneous at apex. Leaf scars opposite nearly whorled, orbicular to elliptical, highly projecting, concave at top; bundle scars 15, blackish, arranged in a circle; scale scars black, conspicuous.

84. C. Bungei C. A. Mey. Tree up to 20 m. high. Bark breaking up into thin, irregular or nearly rectangular, exfoliating flakes. Twigs villose. Lateral buds 1 mm. long, with 8-10 appressed, glabrous, imbricate scales. Leaf scars variable in size, hoof-shaped, concave at top; bundle scars 8, yellowish brown, arranged in a circle; stipule scars absent; scale scars inconspicuous. In other respects similar to *C. ovata*.

ANATOMY OF THE COMMERCIAL TIMBERS OF KANSU

C. H. Yu

The present paper is prepared in connection with Prof. Teng's studies on Kansu forestry. All the samples of wood examined have been collected by Prof. Teng during his investigation trips in Kansu. Nine genera with thirteen species are included. Besides the descriptions of the wood anatomy of the various species, a key for the identification of species is here presented.

In preparing sections, wood blocks of suitable size were first boiled continuously in water until they sink, then softened by soaking in a mixture of equal parts of glycerine and 95% alcohol for 2 to 100 days according to the hardness of the material. After cutting with sliding microtome into sections about 10 μ thick, staining was made with Haidenhain's iron-alum haematoxylin, and safranin was used as a counterstain.

During the progress of the present work, the "Commercial Timbers of the United States" by Brown and Panshin has been relied upon as a guide; "The Technology of Chinese Timbers" (in Chinese) by Y. Tang has also been consulted. The writer regrets that in many cases he is unable to verify Tang's findings.

The writer is indebted to Prof. Teng for his valuable instruction and encouragement during the progress of the work.

TAXUS CHINENSIS (Pilg.) Rehd. (Chinese yew)

Tracheids up to 30 μ in diameter, with fine, conspicuous, widely spaced bands of spiral thickenings; bordered pits in one longitudinal row on the radial walls of spring-wood tracheids; tangential pitting present in the last few rows of summer-wood tracheids, pits in the cross-field 1-4 (generally 2), small and uniform in size in the spring-wood, inner aperture lenticular and included. *Longitudinal parenchyma* wanting. *Rays* uniseriate, or occasionally with paired cells, 1-16 cells and 30-340 μ in height; consisting entirely of ray parenchyma; ray cells filled with gummy contents. *Resin canals* wanting.

PINUS TABULAEFORMIS Carr. (Chinese pitch pine)

Tracheids up to 50 μ in diameter; bordered pits in one longitudinal row or sometimes paired laterally on the radial walls of spring-wood tracheids; tangential pitting wanting or very sporadic in the last few rows of summer-wood tracheids; pits in the cross-field 1-3 (mostly 1, rarely 3), window-like, large, simple or nearly so in the spring-wood. *Longitudinal parenchyma* wanting. *Rays* of two types, (a) uniseriate rays numerous, 1-15 cells and 16-200 μ in height; (b) fusiform rays scattered, with one transverse resin canal, 2-3-seriate through the central portion, tapering above and below to uniseriate margins, 1-5 cells high; ray tracheids present in both types of rays, marginal and interspersed, dentate (the teeth seldom extending to the center of the cell cavity), 1-3 rows on the upper and lower margins of the ray. *Resin canals* of two types, (a) longitudinal canals large, up to 150 μ in diameter, solitary, epithelial cells thin-walled; (b) transverse canals less than 45 μ in diameter; epithelium with 6 thin-walled cells.

ABIES CHENSIENSIS Van Tiegh. (Shensi fir)

Tracheids up to 47 μ in diameter; bordered pits in 1-2 longitudinal rows on the radial walls of spring-wood tracheids; tangential pitting present in the last few rows

of summer-wood tracheids; pits in the cross-field 1-5 (generally 2-3), small and uniform in size in the spring-wood, inner aperture large, ovoid and included. *Longitudinal parenchyma* wanting. *Rays* uniseriate, 1-44 cells and 30-980 μ in height, consisting entirely of ray parenchyma; rays over thirty cells in height frequent; ray cells containing copious rectangular crystals and gummy deposits, with strongly pitted horizontal walls, end walls nodular. *Resin canals* wanting.

PICEA ASPERATA Mast. (Chinese blue spruce)

Tracheids up to 40 μ in diameter; bordered pits in 1-2 longitudinal rows on the radial walls of spring-wood tracheids; torus with slightly scalloped margins; tangential pitting present in the last few rows of summer-wood tracheids; pits in the cross-field 2-7 (generally 3-6), small and uniform in size in the spring-wood, inner aperture narrowly oval and slightly extended. *Longitudinal parenchyma* wanting. *Rays* of two types, (a) uniseriate rays numerous, 1-37 cells and 30-700 μ in height; (b) fusiform rays scattered, with one rarely two transverse resin canals, 2-3-seriate through the central portion, tapering above and below to the uniseriate margins, 1-20 cells in height; ray tracheids present in both types of rays, marginal and interspersed, non-dentate, usually in one or two rows on the upper and lower margins of the ray; 2- or 3-cells-high rays frequently consisting entirely of ray tracheids; the horizontal walls of ray parenchyma strongly pitted, end walls nodular. *Resin canals* of two types, (a) longitudinal canals up to 107 μ in diameter, solitary or 2-3 in a tangential row, epithelium thick-walled; (b) transverse canals less than 40 μ in diameter, epithelium with 6-9 thick-walled cells.

PICEA NEOVEITCHII Mast. (Lowland spruce)

Tracheids up to 51 μ in diameter; bordered pits in 1-2 longitudinal rows on the radial walls of spring-wood tracheids; torus with slightly scalloped margins; tangential pitting present in the last few rows of summer-wood tracheids, pits in the cross-field 2-7 (generally 2-5), small and uniform in size in spring-wood, inner aperture narrowly oval and slightly extended; spiral thickenings present on the walls of spring-wood tracheids. *Longitudinal parenchyma* wanting. *Rays* of two types, (a) uniseriate rays numerous, 1-30 cells and 42-480 μ in height; (b) fusiform rays scattered, with one transverse resin canal, 2-3-seriate through the central portion, tapering above and below to uniseriate margins, 1-10 cells in height; ray tracheids present in both types of rays, with denticulate margins, marginal and interspersed, usually 1-3 rows on the upper and lower margins of the ray; the horizontal walls of ray parenchyma strongly pitted, end walls nodular. *Resin canals* of two types, (a) longitudinal canals up to 110 μ in diameter, solitary or 2-3 in a tangential row, epithelium thick-walled; (b) transverse canals much smaller, with diameters less than 40 μ; epithelium with 7-10 thick-walled cells.

PICEA PURPUREA Mast. (Purple cone spruce)

Tracheids up to 45 μ in diameter; bordered pits in 1-2 longitudinal rows on the radial walls of spring-wood tracheids; torus with slightly scalloped margins; tangential pitting present in the last few rows of summer-wood tracheids; pits in the cross-field 1-7 (generally 2-4), small and uniform in size in spring-wood,

inner aperture narrowly oval and slightly extended. *Longitudinal parenchyma* wanting. *Rays* of two types, (a) uniseriate rays numerous, 1-34 cells and 32-520 μ in height; (b) fusiform rays scattered, with 1-3 transverse resin canals, 2-5-seriate through the central portion, tapering above and below to uniseriate margins, 1-24 cells high; ray tracheids present in both types of rays, marginal and interspersed; with denticulate margins, usually 1-3 rows on the upper and lower margins of the ray; the horizontal walls of ray parenchyma strongly pitted, end walls nodular. *Resin canals* of two types, (a) longitudinal canals with the maximum diameter of 98 μ, solitary or 2-3 in a tangential row, epithelial cells thick-walled; (b) transverse canals much smaller, less than 35 μ; epithelium with 7-9 thick-walled cells.

TSUGA CHINENSIS (Franch.) Pritz. (Chinese hemlock)

Tracheids up to 45 μ in diameter; bordered pits in one row or occasionally paired laterally on the radial walls of spring-wood tracheids; pits membranes with irregularly arranged thickening bars radiating from the torus; tangential pitting present in the last few rows of summer-wood tracheids; pits in the cross-field 1-6 (commonly 2-3), small and uniform in size in the spring-wood, inner aperture lanticular and included. *Longitudinal parenchyma* terminal and sparse, forming a discontinuous line between two growth rings; end walls nodular. *Rays* uniseriate, 1-35 cells and 22-670 μ in height; ray tracheids present, marginal and interspersed, 1-3 rows on the upper and lower margins of the ray; ray parenchyma with gummy deposits, end walls nodular. *Resin canals* wanting.

JUNIPERUS TIBETICA Komar.

Tracheids up to 28 μ in diameter; intercellular spaces rather large; bordered pits in one row on the radial walls of spring-wood tracheids; tangential pitting present in the last few rows of summer-wood tracheids; pits in the cross-field 1-4 (generally 1-2), small and uniform in size in the spring-wood, inner aperture lenticular and included. *Longitudinal parenchyma* abundant, metatracheal or metatracheal diffuse, solitary or 2-several contiguous in a tangential row, with dark gummy deposits. *Rays* uniseriate, 1-8 cells and 16-170 μ in height, rays consisting entirely of ray parenchyma, containing of copious gummy deposits. *Resin canals* wanting.

JUNIPERUS SALTUARIA Rehd. et Wils.

Tracheids up to 25 μ in diameter; intercellular spaces smaller than those in *J. tibetica;* bordered pits in one row on the radial walls of spring-wood tracheids; tangential pitting present in the last few rows of summer-wood tracheids; pits in the cross-field 1-4, small and uniform in size in the spring-wood, inner aperture lenticular and included. *Longitudinal parenchyma* variable in distribution, metatracheal in a given growth ring and then often or metatracheal, or wanting in neighboring rings, containing of dark gummy deposits; cells solitary or 2-several contiguous in a tangential row when metatracheal. *Rays* uniseriate, 1-14 cells and 15-200 μ in height, consisting entirely of ray parenchyma, ray cells containing less gummy deposits than in *J. tibetica. Resin canals* wanting.

POPULUS DAVIDIANA Dode (Chinese quaking aspen)

Diffuse-porous. *Vessels* solitary or in a short radial row or group of 2-4; 180-220 per sq. mm., the largest up to 70 μ in diameter; perforation plates simple; intervessel pits large, 7-9 μ in diameter, orbicular to polygonal, alternately arranged through crowding. *Parenchyma* terminal, 1-2-seriate, forming a narrow, continuous or interrupted line. *Fibers* occasionally galatinous, 14-32 μ in diameter, walls 2-3 μ in thickness. *Rays* simple, fine, about 8 μ in width, up to 560 μ in height, unstoried, uniseriate, homogeneous, about 11 per mm. tangentially; pits leading to vessels numerous, simple, restricted to the upper and lower 1-3 rows marginal cells.

BETULA MANDSHURICA var. SZECHUANICA (Schneid.) Rehd. (Szechuan white birch)

Diffuse-porous. *Vessels* solitary or in a short radial row or group of 2-5; 70-90 per sq. mm., the largest up to 90 μ in diameter; perforation plates scalariform with 7-29 fine bars; intervessel pits bordered, with fused orifices, rounded to angular, small, 2-3 μ in diametet, alternately arranged through crowding. *Parenchyma* of three types, (a) terminal, forming a 2-several-seriate tangential band; (b) metatracheal-diffuse and (c) paratracheal, all very sparse. *Fibers* thin-walled, 2-3 μ in thickness, the diameter up to 15 μ; septate fibers present. *Rays* simple, homogeneous or nearly so, about 9-11 per mm. tangentially, unstoried, 1-3-seriate, 7-15 μ in width, up to 850 μ in height; pits leading to vessels bordered, numerous, not confined to the marginal rows.

QUERCUS SPINOSA David. (Iron oak)

Diffuse-porous. *Vessels* of spring-wood only slightly larger than those of summer-wood, gradually changing size; solitary, arranged into radial bands; 60-90 μ in diameter, 0-30 per sq. mm.; perforation plates simple; walls up to 5 μ in thickness; intertracheary pits rounded to oval, 5-8 μ in diameter, alternately arranged through crowding. *Tracheids* vasicentric, 1-several-seriate, occasionally interrupted by parenchyma. *Parenchyma* of three types, (a) paratracheal sparse; (b) metatracheal aligned into fine, wavy, tangential lines; (c) metatracheal-diffuse restricted to the fiberous tracts. *Fibers* walls 6-9 μ thick, 15-20 μ in diameter, frequently gelatinous. *Rays* homogeneous, unstoried, and of two types; (a) simple rays, fine, uniseriate, numerous, 20 μ in width, 1-30 cells in height; (b) oak-type rays aggregated with fibers, up to 900 μ in width, the highest rays of this type may up to 27 mm.

QUERCUS LIAOTUNGENSIS Koidz. (Liaotung oak).

Ring-porous. *Vessels* 10-40 per sq. mm., and 30-270 μ in diameter; those of spring-wood often occluded with tyloses; those of summer-wood arranged in radially aligned, flameshaped tracts; perforation plate simple; intertracheary pits rounded or oval, 5-10 μ in diameter, alternate, not so crowded as in *Q. spinosa*. *Tracheids* vasicentric, forming 1-5-seriate sheath about the vessels, the sheath frequently interrupted by longitudinal parenchyma or rays. *Parenchyma* frequently crystalliferous; of three types, (a) paratracheal, occasionally intermingled with tracheids and contiguous to the vessels; (b) metatracheal-diffuse, sparse, only restricted to the fiberous tracts; (c) metatracheal forming wavy concentric lines. *Fibers* wall 4-6 μ in thickness, 20-25 μ in diameter; gelatinous and septate fibers present. *Rays* homogeneous, unstoried, and of two types; (a) simple rays fine, numerous, consisting of oil cells; (b) oak-type rays always aggregated with fibers, up to 500 μ in width and 10 mm. in height.

KEY TO SPECIES

1. Wood without vessels (non-porous) 2
1. Wood with vessels (porous) 10
2. Resin canals wanting 3
2. Resin canals present 5
3. Longitudinal parenchyma wanting 4
3. Longitudinal parenchyma present 8
4. Longitudinal tracheids with spiral thickenings .... *Taxus chinensis*
4. Longitudinal tracheids without spiral thickenings .... *Abies chensiensis*
5. Cross-field pitting large, window-like, 1-3; ray tracheids dentate .... *Pinus tabulaeformis*
5. Cross-field pitting small, 1-9, inner aperture narrowly oval and slightly extended; ray tracheids denticulate to non-dentate 6
6. Ray tracheids non-dentate .... *Picea asperata*
6. Ray tracheids denticulate 7
7. Fusiform rays with only one transverse resin canal .... *Picea Neoveitchii*
7. Fusiform rays with 1-3 transverse resin canals .... *Picea purpurea*
8. Ray tracheids present .... *Tsuga chinensis*
8. Ray tracheids wanting 9
9. Longitudinal parenchyma metatracheal or metatracheal-diffuse in some growth rings, wanting in others .... *Juniperus saltuaria*
9. Longitudinal parenchyma metatracheal or metatracheal-diffuse .... *Juniperus tibetica*
10. Ring-porous; oak-type rays present .... *Quercus liaotungensis*
10. Diffuse-porous 11
11. Oak-type rays present .... *Quercus spinosa*
11. Oak-type rays wanting 12
12. Perforation plates simple .... *Populus Davidiana*
12. Perforation plates scalariform .... *Betula mandshurica* var. *szechuanica*

PROPAGATION OF WEEPING WILLOW FROM SEED

S. C. Teng & C. H. Yu

The weeping willow, *Salix babylonica* L., is the common willow of central and southern China. It is usually propagated by means of cuttings. Recent observations made by the writers show that it is also easily raised from seed, although, in this country, this method has never before been contemplated, owing apparently to the minute size and the transient viability of the seed.

In Shanghai, the fruit of the weeping willow ripens about mid-April. The minute seeds enveloped in tufts of long white silky hairs are distributed by wind. Under natural conditions, continuous rain for several days following the dispersal of seeds favors germination. The silky hairs around the seed seem to form a protective covering, preventing the seed from germinating before abundant moisture is available and, on the other hand, retaining the moisture during germination. When moisture conditions are suitable, the minute seed swells up and becomes bright green. The thin delicate papery testa enclosing the unopened cotyledons soon falls off and the cotyledons expand. The radicle is enveloped for a time in the silky hairs until the young root pushes its way down through them. Seedlings never spring up on ground

covered with grass or weeds, but only in places where the mineral soil is exposed and kept constantly moist. Such reproductions are usually neglected and damaged by various agencies, and pass away just as they spring up without being noticed.

A method for raising seedlings of *Salix alba* L. has been suggested by Hoffmann (1). It consists essentially of laying bare a small area of coarse sand near willow seed trees and keeping the place continually damp but not overflowed. This method though simple is, however, not necessary to the production of seedlings of *Salix babylonica*. The results of the following tests show that success may be secured under ordinary nursery conditions.

VIABILITY TESTS. Actual tests have shown that the seeds should be collected as soon as they fall. Those still attached to the trees are usually immature, while those that have been on the ground for a few days are often not viable. After collecting, storage of the seed with the white hairs intact in a dark and tight container will maintain the viability for ten days. The fact that the seeds kept in the container remain viable for a longer period than those left exposed on the ground may be due partly to the low humidity in the container but also to the more or less complete absence of light. It has been found by Nilsson (4) that willow seeds retain their viability better in the dark than when exposed to light. Of course, it is quite possible that the longevity of the seed may be further greatly increased by regulating the humidity and temperature of storage as done by Nakajima (2, 3) with *Salix pierotii* Miq. and *S. japonica* Thunb. But this has not been tried by the writers. Since seasonal conditions require immediate planting after ripening of the seed, for practical purpose there seems to be no necessity for extending the longevity of seed beyond a period of ten days.

PLANTING TESTS. Sowing may be done simply by spreading the hairy seeds on moist seed beds and wetting them with a thorough sprinkle of water. To facilitate sowing, the hairy seeds may be rubbed with fine sand to detach the hairs which then form tangled masses leaving the seed free in mixture with the sand. After picking away the masses of hairs, the sand may be broadcasted over the seed bed. Seeds with hairs detached germinate more readily due to direct contact with the soil, provided the latter is well moistened. They begin to swell up within twenty-four hours and the cotyledons expand within three days. Since the seedlings are very sensitive to drought, it is desirable to cover the seed bed with burlap or straw. When the seeds have germinated, the cover may be removed but the bed should be kept constantly moist either by regular and frequent watering or by shading to conserve moisture. One month after planting, when the true leaves begin to appear, the shade should be removed because the seedlings require an abundance of light and will be suppressed under shade.

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A PROVISIONAL SKETCH OF THE FOREST GEOGRAPHY OF CHINA

S. C. Teng

In the early works on plant geography, as that of Schimper (30), the vegetation of China was dealt with rather inadequately. Diels (7) appears to be the first man to have made important contributions to the phytogeography of China. In his study of the flora of central China in 1905, he emphasized the difference between the vegetation to the north of Tsingling and that to the south of the range. No classification specifically for the vegetation of the whole of China, however, had been attempted until 1931 when Handel-Mazzetti (11) suggested dividing the country into eight phytogeographic provinces. In 1934, Hu (16) following the work of Engler in 1926 (8) on the geographical distribution of the conifers of the world, recognized five broad regions in China, some of which were again subdivided, making a total of ten vegetational provinces. Liou in the same year (23) and subsequently in 1936 (24) proposed eight general regions. In 1944, Li (22) after reviewing the past works, presented a scheme dividing the country into fourteen regions based on the distribution of Araliaceae. He also called attention to the physiographic regions recognized by Cressey (6) and Lee (21). But he did not mention the climatic provinces defined by Chu (4) and Tu (39).

In the present paper an attempt is made to divide the country into regions according to the distribution of climax forest communities correlated with physiography and climate. Alpine tundra, desert-grassland and agricultural plains are not dealt with, as these regions either do not have forest or no longer show any trace of the original vegetation. Eighteen forest regions are herein recognized. The lack of complete information makes it necessary to ignore the many minor formations such as the savanna and the scrub climaxes. The meteorological figures given in the present paper are merely estimates based on data from various sources, particularly the works of Chu (5), Tu (39), and Cressey (6).

Syansk-Altai Region

Under the influence of the Siberian climate, the Syansk, the Khangai and the Altai Mountains in northwestern Mongolia and the northern tip of Sinkiang sustain splendid forests with *Abies sibirica* Ledeb. and *Picea obovata* Ledeb. as climax dominants, and *Larix sibirica* Ledeb. and *Pinus cembra* L. var. *sibirica* Loud. as subclimaxes. Birch-aspen associes is also common. The presence of these species shows distinctly that the forest here is a continuation of the Taiga of Siberia. Roi (28) has pointed out the ecological nature of this region.

Tienshan Region

The Tienshan Range, with peaks rising to heights about 6,000 m., extends across Sinkiang and separates the Zongor Basin on the north from the Tarim Basin on the south. Being surrounded by desert-grassland, it has a very dry climate with annual precipitation probably less than 15 inches. The mean temperature is less than 5° C. and the winter temperatures drop down to -35°C.

The unfavorable climatic conditions cause the fir, which is usually more exacting in moisture requirement, to drop out, resulting in a highly modified form of Taiga

with a single climax dominant, *Picea Schrenkiana* Fisch. & Mey. According to Liou (23) Tienshan is clothed on its north slopes from 1,400 m. up to 2,800 m. with pure spruce forest, while on south slopes only *Salix* and *Populus* grow between 2,200 and 3,500 m. He also found the spruce forest of Tienshan extending to the west end of the Kuenlun Range as far as Yeh-cheng which is located near the northern edge of the range.

KILIEN-INSHAN REGION

This region includes the Kilienshan along the Chinghai-Kansu border, the Alashan in eastern Ningsia, and the Inshan which stretches across the Suiyuan Province. The annual precipitation is probably less than 20 inches, the average temperature less than 7° C., and the extreme minimum about -25° C.

Being similar to Tienshan in its relation to the desert-grassland, this region bears a close resemblance to the former in physiognomy. Ku & Cheo (19), Fung et al (9) and others (23, 26) have contributed informations regarding the forests of this region. Hao (12) has also studied the vegetation of the Kokonor district, but the observations of other workers do not agree with his in many respects. In a previous paper (36) the writer has dealt with the ecological aspect of the Kilienshan forest. On these mountains, *Picea asperata* Mast. is the sole climax dominant at altitudes between 2,000 and 3,500 m., junipers usually form preclimax communities on southerly slopes, birch-aspen associes occasionally occurs with preponderance of aspen, and *Populus cathayana* Rehd. is also present along stream courses. Floristically, the most obvious departure from the Tienshan Region is the occurrence of *Pinus tabulaeformis* Carr. and *Ulmus pumila* L. which tend to bridge the Tienshan to the regions further east.

CHANGPAI REGION

This region embraces the mountains in eastern Manchuria, between the Ussuri and Sungari Rivers southward to the Yalu River. These mountains rise from an altitude about 500 m. to 2,700 m. at the summit of the highest peak. Owing to the proximity of this region to ocean, the annual precipitation ranges from 28 to 40 inches. The average temperature is probably less than 5° C. and the extreme minimum about -36° C.

This region holds the richest store of timber in the country. Its vegetation has been studied by Chen (1), Liou (23) and Kitagawa (18), but their results do not quite agree. The forest here bears a close relation to the Taiga. The climax dominants appear to be *Abies nephrolepis* Maxim. and *Picea jezoensis* (Sieb. & Zucc.) Carr. They cover the mountain slopes up to 2,000 m. *Pinus koraiensis* Sieb. & Zucc. is evidently a subclimax species. *Larix olgensis* Henry is also a subclimax on marshy places. Birch-aspen associes is characteristically present. At altitudes below 1,000 m. *Quercus liaotungensis* Koidz. occurs in mixture with the pine. This is noteworthy since the oak does not appear in the Tienshan and Kilien-Inshan Regions.

KHINGAN REGION

According to Shaw (31), Cressey (6) and others, the Great Khingan has scant vegetation on its western slopes, and its southern part is only sparsely wooded. But a large portion of the northern Khingan and the Little Khingan Mountains in northern

Manchuria are covered with virgin forests. These mountains are all below 2,000 m. in height. The climate is very rigorous, with mean temperature below 0° C. and the extreme minimum about -45° C. The precipitation per annum probably varies from 20 inches in the east to about 12 inches in the west.

From the work of Kitagawa (17), it appears that *Abies holophylla* Maxim. and *Picea jezoensis* (Sieb. & Zucc.) Carr. are climax dominants. Birch-aspen associes is likewise present. Owing to dry climate, the climax species dwindle in importance and *Larix Gmelini* Litvin. assumes climax role, especially toward the west.

Loess-Highland Region

To the north of Tsingling, east of the Tibetan Plateau, and west of the Taiheng Mts. is the Loess-Highland. It extends northeastward to the southern part of Jehol and meets the desert-grassland on the north. Its general land level varies from 800 to 1,500 m., and the mountains mostly do not exceed 2,000 m. in height, only some peaks reaching approximately 2,500 m. The annual precipitation ranges from 20 inches in the east to less than 15 inches in the northwest. The average temperature is about 10° C. and the extreme minimum about -20° C.

Smith (32), Liou (23), Yang(43) and others (25, 27, 33) have made observations on the vegetation of this region, It seems evident that *Abies nephrolepis* Maxim. and *Picea Neoveitchii* Mast. are climax dominants at altitudes above 1,500 m. *Larix Principis-Rupprechtii* Mayr and *Picea asperata* Mast. form subclimax communities. Birch-aspen associes is also common. Below 1,500 m. *Pinus tabulaeformis* Carr., *Quercus liaotungensis* Koidz. and *Q. aliena* Bl. predominate. *Q. liaotungensis* has a higher altitudinal range than *Q. aliena.* The presence of *Abies nephrolepis* shows the affinity of the Loess-Highland with the Changpai Region, while the occurrence of *Picea asperata* and *Pinus tabulaeformis* indicates its relation to the Kilien-Inshan Region with which it is in contact.

The Deforested Loess Highland of Kansu as described by the writer in a previous paper (36) falls under this region. The Hinglungshan forest situated in central Kansu on the border between the Loess Highland and the Subalpine Forest, is a pure stand of *Picea Neoveitchii* Mast. and may also be regarded as belonging to the present region.

Tsingling-Tapa Region

The Tsingling and Tapa Ranges are spurs of the Tibetan Plateau, lying between Weiho on the north and the Red Basin on the south. They form a distinct region comprising southeastern Kansu, southern Shensi, western Honan, northwestern Hupeh and the northern border of Szechuan. The topography here is more rugged than in the Loess Highland. Although the highest peak rises almost to 4,000 m., the land level may drop to 800 m. or lower. The climate is much milder as compared with all the previous regions on the north. The annual precipitation ranges from 23 to 30 inches. The mean temperature is approximately 15° C., and the extreme minimum about -5° C.

This region appears to be the home of *Abies Fargesii* Franch., *A. chensiensis* Van Tiegh., *Tsuga chinensis* (Franch.) Pritz. and *Pinus Armandi* Franch. Characteristic northern elements, as *Picea Neoveitchii, P. asperata,* birch and aspen, are also of common occurrence. Among the southern elements, evergreen oaks and *Cephalotaxus* are not

uncommon, and *Cunninghamia lanceolata* (Lamb.) Hook. makes sporadic appearance. On the other hand, the presence of *Larix Potaninii*, a subclimax species of the Tibetan Plateau, suggests its affinity with the Subalpine Forest. The climax dominants are evidently *Picea Neoveitchii* and *Abies Fargesii*. They occupy the elevations above 1,800 m. At lower altitudes, the forest merges on the south and the east with that of the Yangtze Region; but on the north and the west it consists principally of mixtures of pines and oaks, as exemplified by the conditions in southeastern Kansu described by the writer (36).

Minshan Region

This region is a part of the Tibetan Plateau, including both the northern and southern slopes of Minshan. It embraces southwestern Kansu and the northwestern corner of Szechuan to the east of the Yunling Mts. The elevation ranges from 2,000 m. at the bottoms of valleys to 4,000 m. at the summits of peaks. The annual precipitation for the whole region averages 25 inches. The mean temperature is about 8°C. and the extreme minimum about -20° C.

The ecological characters of the forest of this region have been discussed by the writer in previous papers (36, 37) and the name Northeastern Subalpine Forest has been given. In these papers it has been shown that *Abies Faxoniana* Rehd. & Wils., *Picea purpurea* Mast., and *P. Neoveitchii* Mast. are climax dominants, with the last mentioned species dominating the lower zone. Having taken the regions outside the Tibetan Plateau into consideration, it at once becomes evident that the lower zone occupied by the *Picea Neoveitchii* consociation merely represents the ecotone between the Tsingling-Tapa Region and the present one. It may be desirable to shift the eastern boundary of this region, previously delimited by the writer, to the west so as to include as much as possible the area dominated by *Picea Neoveitchii* in the Tsingling-Tapa Region. In this connection it may also be pointed out that *Abies sutchuenensis* (Franch.) Rehd. & Wils. as found in Minshan may be identical with *Abies Fargesii*. Its occurrence here probably also represent the ecotone between the two associations.

The close affinity of the Minshan with the Tsingling-Tapa Region is clearly revealed by what has been stated above. In a previous paper (37) the writer has pointed out that the Towho Watershed in the northern part of the Minshan Region represents a transitional zone between Kilienshan and the remaining parts of the East-Tibetan Plateau, as shown by the occurrence of birch-aspen associes, of *Picea asperata* subclimax, and of *Pinus tabulaeformis, P. Armandi* and *Quercus liaotungensis* on the foothills.

Northern Sikang Region

This region covers the territory on the northern part of eastern Sikang, north of Tashuehshan which extends from Batang to Tachienlu. It corresponds to the Northern Subalpine Forest in the writer's previous report (37). The general elevation of the region is over 3,000 m. The climatic conditions are probably about the same as in the Minshan Region. Both temperature and moisture decrease from east to west.

Ku & Cheo (19) have supplied much information concerning the forests of this region. The climax dominants are *Abies squamata* Mast. and *Picea Balfouriana* Rehd. & Wils. *Betula albo-sinensis* Burk. is found only in negligible amounts. *Populus*

Davidiana Dode disappears owing to the high altitude. *Larix Potaninii* Batal., *Pinus tabulaeformis* var. *densata* (Mast.) Rehd., and *Quercus semicarpifolia* Smith play subclimax roles. Here and in the following region, the most typical expression of the Subalpine Forest is found.

Southern Sikang Region

This region, previously called the Southern Subalpine Forest by the writer (37), consists of the southern part of eastern Sikang and a small portion of northwestern Yunnan, including the area from Tashuehshan in Sikang southward to Kienchuan in Yunnan. It is limited on the east approximately by a line running from Minya Gonka near Tachienlu southward touching the eastern boundary of the Muli territory to Yungsheng in northwestern Yunnan. On the west, its boundary follows a series of high ridges extending from Kienchuan northwestward at first along the Yangtze-Mekong Divide and then the Mekong-Salween Divide to the border of Yunnan. The altitude varies approximately from 2,400 to over 5,000 m. In the valleys near its southern border, the mean temperature is somewhere around 14°C. with the minimum about -7°C. But in the interior the average temperature probably does not exceed 11°C. and the minimum may reach -10°C. or lower. The precipitation averages about 35 inches per annum.

As shown by Ku & Cheo (19) and the writer (35) the climax community consists chiefly of *Picea likiangensis* (Franch.) Pritz. and *Abies Georgei* Orr. But the latter appears to be synonymous with *Abies Forrestii* Craib. and, being a later name, should not be retained. The climax forest then becomes *Picea likiangensis-Abies Forrestii* association. Here *Larix Potaninii* and *Quercus semicarpifolia* thrive, and *Betula albo-sinensis* occurs in limited quantities as in the previous region. Meanwhile, *Pinus Armandi* and *Abies chensiensis* appear quite frequently, and *Pinus yunnanensis* Franch. assumes subclimax importance, taking the place of *P. tabulaeformis* var. *densata*.

Southeastern Sikang Region

As its name implies, this region lies in the southeastern corner of Sikang, to the east of Tachienlu. It was previously described by the writer (37) under the name Southeastern Subalpine Forest. Being on the fringe of the Tibetan Plateau, the elevation in some valleys drops down to about 1,000 m. although some peaks rise to over 5,000 m. The mean temperature is about 15°C. and the extreme minimum about -2°C. The precipitation probably exceeds 40 inches per annum.

According to the observations of the writer (34) and the results of forest surveys by Cheng et al (2) and others, the climax dominants are here represented by *Abies Faberi* (Mast.) Craib. and *Picea brachytyla* (Franch.) Pritz. accompanied by *Tsuga chinensis* (Franch.) Pritz. and *T. yunnanensis* (Franch.) Mast., particularly the latter. *Betula albo-sinensis* Burk. is present in comparatively significant quantities. But larch is rarely found, and the pines (*P. Armandi* and *P. yunnanensis*) are uncommon.

Central Yunnan Region

This is a tableland consisting of central and northeastern parts of Yunnan, the northwestern corner of Kweichow, and the southeastern tip of Sikang. It merges with the Tibetan Plateau on the north and the northwest, and is limited by the Red River

on the southwest. Its eastern boundary is marked roughly by a line passing from Yuan-kiang through Kaiyuan and Loping to Tating in Kweichow and ending at the border of Szechuan. The elevation ranges from 1,600 to 2,600 m. The total rainfall is about 40 inches per annum. The mean temperature is somewhere around 15°C. and the extreme minimum about -5°C.

Both Handel-Mazzetti (10) and Wang (40) have shown that the forest of this region is essentially a mixture of pine and oaks. Wang states: "The pine forest attains its best development on the tableland of Middle Yunnan ranging from 1,600 to 2,600 meters. Good-sized pines appear as scattered individual trees forming pure to nearly close stands. *Keteleeria Davidiana* is often found scattered among the pines but rarely occurs in abundance together. Some species of oaks and *Schima Wallichii* are often associated in the pine forest especially in shallow valleys." As for the component species, he lists *Pinus yunnanensis* Franch., *P. Armandi* Franch., *Keteleeria Davidiana* (Franch.) Beiss., *Castanopsis Delavayi* Franch., *Quercus Griffithii* Hook. f. et Thoms., *Q. variabilis* Bl., *Schima Wallichii* (DC.) Choisy, etc.

Yangtze Region

As here delimited, this region embraces chiefly the drainage areas of the Yangtze and Chientang Rivers, to the east of Sikang and Yunnan and south of Tapashan, excluding of course all the agricultural plains as previously understood. It covers almost the whole of Kweichow and of Hunan, southwestern Hupeh, northern and western Kiangsi, southern Anhwei, central Chekiang, and also the rims of the Red Basin of Szechuan, portions of northern Kwangsi and southeastern Yunnan. The altitude ranges from 400 to 2,000 m. The total rainfall amounts to about 50 inches per annum. The mean temperature approximates 17.5°C. and the extreme minimum varies from about -4°C. in the west to about -6°C. in the east.

Though this region is vast in extent, its unity has been shown by Hu (14, 15) who states that "the flora of southeastern Anhwei, northern Kiangsi and Chekiang is more related to that of central China, while the vegetation of the southern part of Kiangsi and Chekiang has decidedly subtropical affinities." The species occurring in this region are numerous. *Cunninghamia lanceolata* (Lamb.) Hook., *Pinus Massoniana* Lamb., *Cupressus funebris* Endl., and *Liquidambar formosana* Hance are the most abundant and prevalent. *Cryptomeria japonica* D. Don, *Pseudolarix Kaempferi* (Lindl.) Gord., *Tsuga chinensis* (Franch.) Pritz., *Pseudotsuga sinensis* Dode, and many broad-leaved species are also present but never in great abundance. In his analysis of the flora of Hwangshan, Chien (3) opines that the vegetation there is "essentially of a type of deciduous forest". But he adds that "no dominant trees are noted in the forest".

It appears to the writer that among all the species present in this region, *Fagus longipetiolata* Seem. is probably the most tolerant of shade. Occasional relicts of this species throughout the region, especially in the west where small pure stands have been found (29), suggest its being the climax dominant at an altitudinal zone between 1,000 and 2,000 m. *Liquidambar formosana* is most likely the other climax dominant of the association, being rather tolerant and prevalently abundant between sea level and 1,000 m. Some other broadleaved trees, particularly certain species of *Acer* and

Castanopsis, are perhaps also important members in the climax community which may be considered as a beech-maple association. Although *Cunninghamia lanceolata* forms extensive pure stands at altitudes between sea level and 2,000 m., assuming climax importance, it is to be regarded as subclimax. While it is more shade-bearing than the rest of the conifers in the region, with the exception of *Tsuga chinensis,* it is considered intermediate in tolerance. The *Pinus Massoniana* consocies is undoubtedly of a subseral nature.

Southeastern Maritime Region

Lying to the south of Nanling and Wuyishan, this region covers the southern portion of Chekiang, the whole of Fukien, the southern and southeastern part of Kiangsi, the larger part of Kwangtung except its southwestern end, and the eastern and central portion of Kwangsi. It is hilly throughout, but the elevations rarely exceed 2,000 m. The climate, being warm and wet, is subtropical. Snow is practically unknown, and the winter temperature rarely drops to freezing. The mean temperature approximates 21°C. and the annual rainfall exceeds 60 inches.

The floristic characters of the present region are marked by the disappearance of *Fagus* and *Pseudolarix,* and by the presence of *Fokienia Hodginsii* Henry & Thomas, *Glyptostrobus pensilis* K. Koch, *Keteleeria Fortunei* (Murr.) Carr., *Ficus retusa* L., etc. As in the Yangtze Region, *Cunninghamia lanceolata, Pinus Massoniana, Cupressus funebris, Cryptomeria japonica,* and *Liquidambar formosana* are common. Though *Cunninghamia lanceolata* and *Pinus Massoniana* occur in preponderating abundance, they evidently represent seral stages. The climax forest is an evergreen oak-laurel association with dominant species belonging to such genera as *Castanopsis, Lithocarpus, Quercus, Cinnamomum, Machilus,* etc. The devastation of the original forest and the complex nature of the flora of this region make it difficult to determine the climax dominants of the association without resorting to experimental investigations.

Taiwan Region

The island of Taiwan is situated to the southeast of the mainland of China. It is very mountainous, with great altitudinal range. The average height of the mountains is about 3,000 m. Several peaks are over 3,600 m. and the highest one attains an altitude approaching 4,000 m. Owing to the influence of the ocean, the average temperature is higher and the rainfall more abundant than the corresponding latitudes on the mainland. The climate is diversified, being increasingly tropical toward the south and at lower elevations. The mean temperature varies from 22°C. in the north to about 24°C. in the south. It is undoubtedly lower on the high mountains. The annual rainfall varies from about 60 inches in the south to over 100 inches in the north.

Detailed information concerning the vegetation of the island may be found in the papers by Wilson (41), Kudo (20), Yamamoto (42) and others. In general, it may be said that all the alluvial plains and most of the foothills have long been brought under cultivation, and forests are found only in the high mountains. At altitudes over 2,000 m., the fir-cedar association predominates, which constitutes a coniferous forest of unrivaled magnificence. The climax dominants are obviously *Chamaecyparis formosensis* Matsum., *C. obtusa* Sieb. & Zucc. and *Abies Kawakamii* (Hay.) Ito. The *Chamaecyparis*

consociation occupies the zone between 2,000 and 3,000 m. in which *Taiwania cryptomerioides* Hay. and *Cunninghamia Konishii* Hay. are found as scattered individuals. The *Abies* consociation dominates the elevations between 3,000 and 3,800 m. In its lower portion are found scattered trees of *Picea morrisonicola* Hay. and *Tsuga chinensis* Pritz. *Pinus Armandi* and *P. taiwanensis* Hay. often appear on the cut-over areas in the coniferous forests.

Below 2,000 m. broadleaved forests belonging to the oak-laurel association occur, in which bamboos, tree ferns, lianas, and epiphytes abound. The predominating trees are mostly evergreen Fagaceous and Lauraceous species belonging to such genera as *Quercus, Castanopsis, Machilus, Cinnamomum, Beilschmiedia,* etc. *Alnus* and *Liquidambar* frequently appear in the clearings. In these forests are also found certain conifers as *Keteleeria Davidiana* (Franch.) Beiss., *Libocedrus macrolepis* (Kurz) Benth., *Pseudotsuga Wilsoniana* Hay., *Pinus Massoniana* Lamb., etc. The occurrence of these species as well as *Tsuga chinensis, Pinus Armandi* and *Taiwania cryptomerioides* indicates the close relationship between the Taiwan flora and that of the mainland of China.

Luichow-Hainan Region

This region is mainly tropical. It lies south of the Tropic of Cancer and extends from the mouth of Sikiang westward to the border of Tonkin, comprising the island of Hainan, the Luichow Peninsula, the southwestern end of Kwangtung and the southern part of Kwangsi. It is a region of low hills with summits varying from 400 to 800 m. in elevation. Only the Five Finger Mountains in Hainan rise to about 2,000 m. in height. However, northern Hainan, and the Luichow Peninsula including a narrow coastal fringe of Kwangtung are plains. Owing to the southerly latitude and comparatively low altitudes, the temperature is high all the year round. The mean temperature varies from 23°C. in the north to about 25°C. in the south. The winter temperature rarely drops below 5°C. The amount of annual rainful varies from 60 inches in the north to probably over 100 inches in the south. Over much of the region the total rainfall per annum is in excess of 80 inches.

The original forests in this region have mostly been destroyed save on the mountains of southern Hainan where virgin stands still remain. As found by Hosokawa (13), the forests of Hainan may be divided into two altitudinal zones. Below 900 m. tropical rain forest prevails, consisting of such genera as *Canarium, Terminalia, Hopea, Litchi, Homalium, Vatica, Ficus,* etc. At elevations from 900 m. up, oak-laurel forest similar to that of Taiwan predominates. Here *Quercus, Castanopsis, Cinnamomum, Phoebe, Litsea, Magnolia, Michelia, Aglaia,* etc. are the principal constituents. Bamboos, tree ferns, lianas, epiphytes are also common. Where these broadleaved forests are destroyed, the areas are usually taken over by *Eugenia, Liquidambar, Macaranga,* etc. Among the coniferous species occurring in this region are *Podocarpus javanicus* Merr., *Dacrydium elatum* (Roxb.) Wall., *Pinus Merkusii* Jungh. & de Vr., *P. morrisonicola* Hay., *P. Massoniana* Lamb., *Libocedrus macrolepis* (Kurz) Benth. and *Cephalotaxus drupacea* Sieb. & Zucc. var. *sinensis* Rehd. & Wils. These are mostly found as scattered individuals in the broadleaved forests. The strong Indo-Malayan affinity as indicated by the presence of the first three species above mentioned distinguishes the Luichow-Hainan Region from the remaining tropical or subtropical regions.

Salween-Mekong Region

As its name indicates, this region consists mainly of the Salween and Mekong valleys within the Yunnan Province. Its northeastern boundary follows approximately the course of the Red River and extends northwestward along the Mekong-Yangtze Divide and then the Salween-Mekong Divide to the extreme northwestern corner of Yunnan. A narrow strip of tropical territory along the southeastern border of Yunnan and along the Red River valley is also included in the present region. The elevation gradually lowers from over 3,000 m. on the extreme northwest to about 1,000 m. on the south. The total rainfall approaches 60 inches per annum. The mean temperature increases from about 14°C. on the north to about 20°C. on the south. While the winter temperature on the south never drops down to freezing, it reaches as low as -7°C. on the north.

The northwestern portion of this region is actually a part of the Tibetan Plateau. Owing to the strong monsoon influence, the vegetation here differs from the remaining parts of the plateau, being more closely akin to the Taiwan flora than to that of any other region. Even the Southern Sikang Region has little in common with the present one in spite of their contiguity.

In this region, three forest zones may be recognized. At altitudes between 2,800 and 4,000 m., mainly at the northwestern part, coniferous forest predominates. It is apparently a fir-hemlock association with *Abies Delavayi* Franch. and *Tsuga yunnanensis* Mast. as the climax dominants. From 2,800 m. down to 1,500 m., the forest is essentially an evergreen oak-laurel association with such dominant genera as *Castanopsis, Lithocarpus, Quercus, Litsea, Cinnamomum, Beilschmiedia, Magnolia, Schima,* etc. Giant bamboos, tree ferns, lianas, and epiphytes are common. Many interesting conifers as *Taiwania cryptomerioides* Hay. *Pseudotsuga Wilsoniana* Hay., *Libocedrus macrolepis* (Kurz) Benth. are also found, showing close affinity with the Taiwan flora. Below 1,500 m., chiefly in southern Yunnan, tropical rain forest occurs. According to Wang (40) *Canarium, Dysoxylum, Cedrela, Litchi, Terminalia, Garcinia, Ficus,* etc. are the dominant genera. *Fokienia Kawaii* Hay. and *Pinus insularis* Endl. have also been reported from this region. The former forms extensive pure stands at the Yunnan-Tonkin border, and the latter which is evidently an Indo-Malayan element, grows in great abundance at southwestern Yunnan especially around Szemao.

Tsangpo Gorge Region

In the valley of the Tsangpo River which traverses southern Tibet and southwestern Sikang, forests may be found in some of the deep gorges at its eastern part. They exist only in the gorges since the level of the land surface is generally above 4,000 m. Being strongly influenced by the monsoon, the climate in the valley is quite humid, with annual rainfall amounting to over 100 inches. The mean temperature is about 9°C. and the extreme minimum is probably about -15°C.

The forest flora here is distinctly Himalayan, and belongs to the eastern Himalayan region as described by Troup (38). Above 2,500 m. it consists chiefly of conifers, namely, *Abies spectabilis* (D. Don) Spach, *Tsuga dumosa* (D. Don) Eichl., *Picea spinulosa* (Griff.) Henry, and *Larix Griffithiana* Carr. The first two species appear to

be the climax dominants. The fir consociation occupies the altitudes between 3,000 and 4,000 m., and the hemlock between 2,500 and 3,000 m. The spruce and the larch occur in mixture with both fir and hemlock. Between 1,500 m. and 2,500 m., evergreen oak-laurel forest occurs, and *Pinus Griffithii* McClelland grows frequently in mixture with broadleaved species. Below 1,500 m., toward the Burmese border, the forest is distinctly tropical.

DISCUSSION

The above eighteen regions may be grouped under seven formations:

1. SUBBOREAL FOREST. This formation is so named in order to be distinguished from and to show its relation to the Taiga of Siberia and the Boreal Forest of North America, both of which have more northerly latitude. Lying to the north of the Tibetan Tundra and the Tsingling, it stretches across the country as a curved broken belt encircling the desert-grassland of Mongolia and Sinkiang, and consists of the Syansk-Altai, Tienshan, Kilien-Inshan, Changpai, Khingan, and Loess-Highland Regions.

Here the mean temperatures are generally low, never exceeding 10°C., and the moisture conditions are the most varied. With the decrease in annual precipitation from east to west, the forests toward the west become proportionally more xerophytic in character with simpler composition and smaller stature of trees. The whole formation is characterized by the dominance of conifers and by the presence of birch-aspen associes. In a strict sense, the climax dominants of the Subboreal Forest are spruce and fir. But the subclimax larch often assumes climax role as in the Khingan Region, or the fir often drops out due to unfavorable climatic conditions as in the Tienshan and Kilien-Inshan Regions.

2. SUBALPINE FOREST. This lies on the eastern slope of the Tibetan Plateau to the south of the Kuenlun Range and extends from Minshan eastward along the Tsingling to Funiu Mts. in western Honan, and also along Tapashan to northwestern Hupeh. It occupies an altitudinal zone generally from 2,000 m. up to timberline. The Tsingling-Tapa, Minshan, Northern Sikang, Southern Sikang, and Southeastern Sikang Regions belong to this formation. But the Tsingling-Tapa Region is a meeting ground of at least three climaxes. In areas where the elevations are too low for the spruce and fir, montane climax develops. Above the montane zone, both subalpine and subboreal elements are found. But the region occupies such a large territory that it cannot well be regarded merely as an ecotone. Since all the characteristic subalpine species are present over most of the region, it seems logical to assign it to this climax.

The Subalpine Forest is closely related to the Subboreal Forest in composition, since *Picea*, *Abies* and *Larix* are common in both formations. It appears to be the remains of the southward extension of the Subboreal Forest during a cold period in the geologic past. In fact some of the subboreal species, such as *Picea Neoveitchii* and *P. asperata* are still retained here. The birch-aspen associes characteristic of the Subboreal Forest is also present in the northern part of the present formation. Even in the southern portion of East-Tibetan Plateau, *Betula albo-sinensis* Burk. still remains. This formation differs from the previous one chiefly in its southern latitude, higher altitude, generally higher average temperature and annual precipitation and, consequently, greater number of

tree species. *Tsuga* and *Cephalotaxus* which do not exist in the Subboreal Forest, appear in this formation.

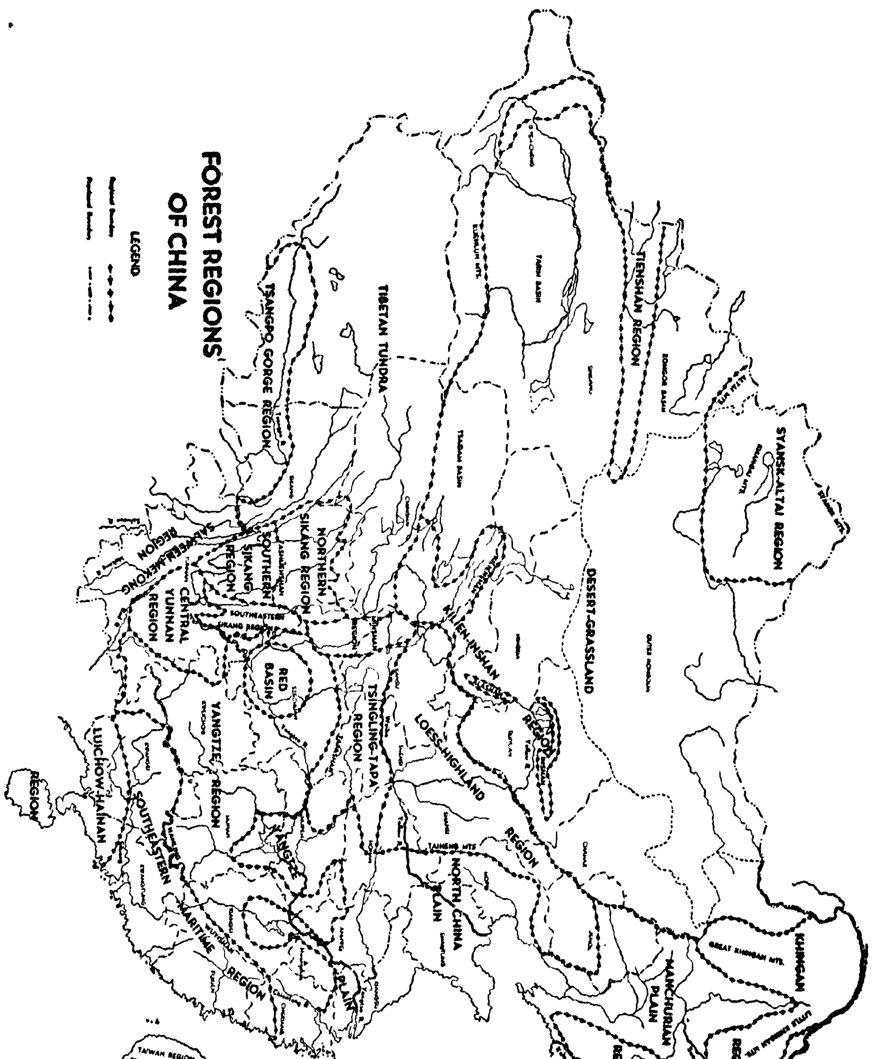
3. Montane Forest. This formation usually occurs along the lower margin of the Subalpine Forest, frequently mingling with the latter. It is characterized by the dominance of *Pinus* and *Quercus*, and finds its best expression in the Central Yunnan Region where the tableland extends out southeastward in gentle gradient from the Tibetan Plateau, forming a broad transition from the latter to the lower level. This formation is also well manifested at places in the Tsingling-Tapa Region below the the spruce-fir formation. In the Loess-Highland Region of the Subboreal Forest, it is likewise extensively developed at altitudes below 1,500 m. Elsewhere it is negligible in extent owing obviously to a sudden drop in elevation at the edge of the Tibetan Plateau, allowing little space for the development of the Montane Forest.

4. Deciduous Forest. This formation is represented only by the Yangtze Region which apparently belongs to the beech-maple association. Originally it includes probably also the plain regions which are not considered in the present work as already pointed out. It is essentially a temperate forest, in contrast with the coniferous forests on the one hand and the evergreen broadleaved forests on the other. It is an outcome of moderate temperatures and rainfall which represent a climatic condition intermediate between the other two groups of forests. Due to destruction of the original forest, the subclimax *Cunninghamia* has been playing a climax role probably for centuries. For this reason, the northern and western boundaries of the Yangtze Region have been determined merely by tracing the distribution of the *Cunninghamia*.

5. Subtropical Forest. This formation includes the whole of the Southeastern Maritime Region, the foothill zone of the Taiwan Region, the mountains in the Luichow-Hainan Region above the elevation of 900 m., the altitudinal zone between 1,500 and 2,800 m. in the Salween-Mekong Region, and also between 1,500 and 2,500 m. in the Tsangpo Gorge Region. It is a direct outcome of the warm and wet climate. The climax dominants are evergreen broadleaved species belonging mainly to Fagaceae and Lauraceae. Their exact determination has to wait, pending future intensive ecological studies.

6. Tropical Forest. This formation lies mainly to the south of the Tropic of Cancer, including practically the whole of the Luichow-Hainan Region except the mountains above 900 m., the southern portion of the Salween-Mekong Region, and also the southeastern edge of the Tsangpo Gorge Region near the Burmese border. Its northern limit may extend to the north of the Tropic of Cancer along depressed streamways or retreat southward with the advance of mountains. The number of dominants in this formation is naturally very large. The major dominant genera have been listed under the various regions concerned. No reiteration is deemed necessary.

7. Monsoon Subalpine Forest. This formation is so named because it consists of forests on high altitude within the monsoon belt, with dominant members related to but different from those of the Subalpine Forest. It is the product of moderate temperature and abundant rainfall. It includes the altitudinal zones between 2,000 and 3,800 m. in the Taiwan Region, between 2,800 and 4,000 m. in the Salween-Mekong Region, and between 2,500 and 4,000 m. in the Tsangpo Gorge Region.


FOREST REGIONS OF CHINA
LEGEND
TIENSHAN REGION
TARIM BASIN
TIBETAN TUNDRA
TSANGPO GORGE REGION
SYANSK-ALTAI REGION
DESERT-GRASSLAND
NORTHERN SIKANG REGION
SOUTHERN SIKANG REGION
SALWEEN-MEKONG REGION
CENTRAL YUNNAN REGION
RED BASIN
TSINGLING-TAPA REGION
LOESSHIGHLAND REGION
YANGTZE REGION
YANGTZE PLAIN
LUICHOW-HAINAN REGION
SOUTHEASTERN MARITIME REGION
TAIHENG MTS
NORTH CHINA PLAIN
MANCHURIAN PLAIN
GREAT KHINGAN MTS.
KHINGAN REGION
CHANGPAI REGION
TAIWAN REGION

LIST OF FOREST FORMATIONS AND ASSOCIATIONS OF CHINA

SUBBOREAL FOREST: Spruce-larch Formation

1. *Picea obovata - Abies sibirica* association: Syansk-Altai Region
   (Larch subclimax: *Larix sibirica* consocies)
2. *Picea Schrenkiana* consociation: Tienshan Region
3. *Picea asperata* consociation: Kilien-Inshan Region
4. *Picea jezoensis - Abies nephrolepis* association: Changpai Region (above 1,000 m.)
5. *Picea jezoensis - Abies holophylla* association: Khingan Region
   (Larch subclimax: *Larix Gmelini* consocies)
6. *Picea Neoveitchii - Abies nephrolepis* association: Loess-Highland Region (above 1,500 m.)
   (Larch subclimax: *Larix Principis-Rupprechtii* consocies)

SUBALPINE FOREST: Spruce-fir Formation

1. *Picea Neoveitchii - Abies Fargesii* association: Tsingling-Tapa Region (above 1,800 m.)
2. *Picea purpurea - Abies Faxoniana* association: Minshan Region
3. *Picea Balfouriana - Abies squamata* association: Northern Sikang Region
4. *Picea likiangensis - Abies Forrestii* association: Southern Sikang Region
5. *Picea brachytyla - Abies Faberi* association: Southeastern Sikang Region

MONSOON SUBALPINE FOREST: Fir-hemlock Formation

1. *Abies Delavayi - Tsuga yunnanensis* association: Salween-Mekong Region (above 2,800 m.)
2. *Abies spectabilis - Tsuga dumosa* association: Tsangpo Gorge Region (above 2,500 m.)
3. *Abies Kawakamii - Chamaecyparis formosensis* association: Taiwan Region (above 2,000 m.)

MONTANE FOREST: Pine-oak Formation

1. *Pinus Armandi - Castanopsis Delavayi* association: Central Yunnan Region
   (*Pinus yunnanensis* subclimax)
2. *Pinus Armandi - Quercus acuteserrata* association: Tsingling-Tapa Region (above 1,800 m.)
3. *Pinus tabulaeformis - Quercus liaotungensis* association: Loess-Highland Region (below 1,500 m.)
4. *Pinus koraiensis - Quercus liaotungensis* association: Changpai Region (below 1,000 m.)

DECIDUOUS FOREST: Beech-maple Formation

1. *Fagus longipetiolata - Liquidambar formosana* association: Yangtze Region
   (Cunninghamia subclimax: *Cunninghamia lanceolata* consocies)

SUBTROPICAL FOREST: Oak-laurel Formation

(*Cunninghamia lanceolata* consocies in Southeastern Maritime Region)

TROPICAL CLIMAXES

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CYTOLOGICAL STUDIES ON SUGARCANE AND ITS RELATIVES. I. HYBRIDS BETWEEN SACCHARUM OFFICINARUM, MISCANTHUS JAPONICUS AND SACCHARUM SPONTANEUM*

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The present-day noblecane varieties, though predominantly *S. officinarum* L., are contaminated with few to many chromosomes of *S. spontaneum* L. They are easily crossed with other species of *Saccharum* such as *S. spontaneum* L., *S. robustum* Jeswiet, *S. narenga* Wallich, *S. berberi* Jeswiet and others. They can also be crossed readily with other related genera in the tribe Andropogoneae, such as *Erianthus, Zea, Imperata, Sorghum* etc; and with the widely separated genus *Bambusa* of the tribe Bambuseae (See literature citation of Moriya, 7. and Janaki-Ammal, 4). Since the cytological work of the varieties of noblecane, and its interspecific and intergeneric crosses, were done mostly with root tip counts, very little was known about the meiotic mitosis. It is very unfortunate indeed that many deductions based chiefly or solely on root tip counts seem to be rather ill-founded. In order to clarify the situation in understanding the pairing of different sets of chromosomes when they are brought together in a cross, or perhaps the identity of the chromosomes if this could be determined, study of the behavior in meiosis would be essential. Perhaps, this would ultimately lead to the uncovering of the phylogenetic development of the different species in the genus *Saccharum*, and of the different genera in the tribes Andropogoneae and Bambuseae. It is with this end in view that the cytological studies involving the hybrids of *S. officinarum, M. japonicus*, and *S. spontaneum* are reported on here.

MATERIAL AND METHODS

Since "V. J-Day", the Island of Taiwan has been receded to China. The varieties and crossed hybrids of the sugarcane were mostly left intact in the Pingtung Station. Among these, a few hybrid lines between P.O.J. 2725 and *M. japonicus* were kept by the Japanese workers ever since 1933, when the original cross was made. (Acquisition numbers of these are 33-84, 33-85, 33-86, 33-94, 33-95, 33–96 and 33–98). One of the hybrid lines was crossed with *S. spontaneum* var. *Glagah* (2n=112), by one of us, (acquisition number 46-43). The flowers were fixed in acetic alcohol solution (1-3) when the spikes were just about to emerge from the boot. After 24 hours, they were transferred, by several changes, to 70% alcohol and stored in the refrigerator. Even with this precaution, some of the material became spoiled after a couple of months in storage. The Feulgen reaction was used on smears, but they were not satisfactory because of the clumping and bunching together of chromosomes making their study almost impossible; therefore the aceto-carmine smear method was used exclusively for these studies. In making the smears, just sufficient pressure was applied to the coverglass, after the material had been teased out in the tiny carmine drop. This caused the chromosomes in metaphase to spread out widely on the plate; but at the same time, many cells were crushed, and the chromosomes in some plates were so smashed up as to lose altogether their identity. Nevertheless, there were some good

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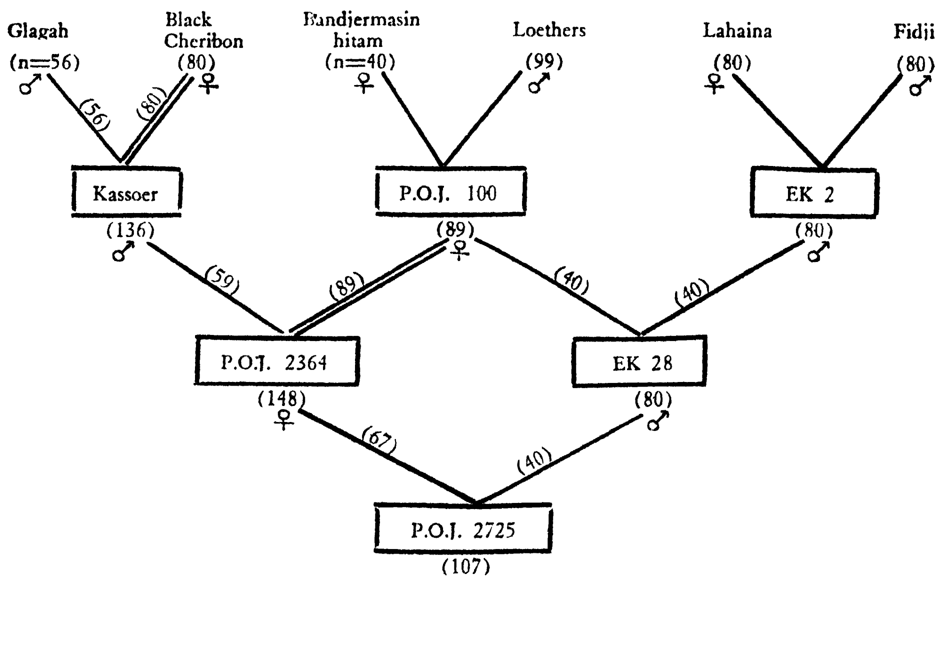
plates left for careful study. Heating the slides to clear the cytoplasm, and further to spread the chromosomes, was a very essential procedure but necessitated careful manipulation and control. After heating, the slide was destained by passing under the cover slip a few drops of 45% acetic solution. The solution was drawn across by applying blotting paper to the opposite side of the coverslip. Slides were repeatedly examined under the microscope so as to control the degree of destaining. A drop of carmine was applied for restaining if destaining had gone too far.

For root-tips, the cuttings were rooted in sand beds. When the roots grew to about 3 or 4 mm. long, they were ready for fixation. The cuttings were placed in a rather cool place the night previous to fixation. On the day of fixation they were then taken to a warmer place about 30 °C, and well watered. Two or three hours after such treatment, the growth of the roots was at the maximum, thus providing a multitude of division figures. The cuttings were then removed, either to a refrigerator, or to a container in which ice-chips had been packed, for one hour. This prefreezing prior to fixation was found essential for the condensation and shortening of the chromosomes, so that they were spread out on the metaphase plates, thus facilitating counting. Root-tips were fixed in Randolph's "Craf" solution, and this proved to be quite satisfactory. Feulgen reaction smears were tried, but they were not as satisfactory as sections cut to 15 μ thickness and stained with crystal violet. Often there were only few figures at the right orientation for counting. The drawings were made with the help of camera lucida at table level.

OBSERVATIONS

P.O.J. 2725.

Since P.O.J. 2725 was male sterile, it was used as a female plant in many crosses in the past. The parentage of P.O.J. 2725 is illustrated in the following diagram (modified from Moriya 6.):



The diploid number of P.O.J. 2725 was confirmed to be 107. The chromosomal configurations are shown in Fig. 1 and chromosomal constitution is given in Table 1.

TABLE 1. CHROMOSOMAL CONSTITUTION OF P.O.J. 2725

Stage	Frequency	Bivalents	Univalents	Total	Remarks
Diakinesis	3	47	13	107	
	2	48	11	107	
	1	49	9	107	
Metaphase	2	48	11	107	
	1	42	23	107	Some precocious divisions.
Total	9				

There were 9-13 univalents encountered in the few cells studied. It might be expected that these univalents would lag behind the others in anaphase I and telophase I. This was exactly what we found (Fig. 2). In some cells, the univalents would go to the poles at random without any division, while in others, they would lag behind on the equatorial plate, mostly split into two. In the second telophase, there were many laggards that would ultimately form micronuclei to be excluded from the nuclei of the tetrad (Fig. 3).

Should the bivalents go to the poles regularly, and the univalents be distributed at random, the gametes produced would have chromosomes ranging from 47 (with complete elimination of all the univalents) to 60 (with the inclusion of all the univalents) with a mean of 53 or 54 if the cell should start with 47^{II} 13^{I}. This, however, would disagree widely with the finding of Moriya (6.) in his sugarcane-sorghum hybrid, in which the intermediate and dwarf types invariably had 54 chromosomes contributed by the female parent. The results obtained from sugarcane-*Miscanthus* cross, to be described later, are found to verify the assumption just made, and to invalidate the findings of Moriya (6.). From the history of the origin of P.O.J. 2725 as illustrated in the diagram, there were roughly 100 chromosomes coming from *S. officinarum* after two successive doublings; and the other 7 from Glagah and Loethers.

MISCANTHUS JAPONICUS L.

Meiosis was not studied because these plants flowered a little too early to make it available for the collection of material. Bremer found it to have 19 pairs of chromosomes (citation from Moriya 7). From the mitotic figures in the root tips, it has 38 chromosomes (Fig. 25).

It seemed therefore that the gametes produced by *M. japonicus* would have 19 chromosomes.

F_1 OF P.O.J. 2725 x M. JAPONICUS

There were altogether 12 lines left from the original cross made by the Japanese workers. Facts concerning the number of seedlings obtained from the original cross, the existence of dwarf plants as in the case of sugarcane-sorghum hybrid, (Moriya 6.), and the occurrence of white seedling as in the case of Simpson-noblecane × *S. robustum* (Brandes 2.), are all unknown to us, since no detailed records were kept. Of the twelve remaining lines, seven lines were studied cytologically, and these will be discussed below.

(a). LINE 33-84. This was an intermediate type with rather slender stalks and low sugar content (Observation 4, Table 7); it had 72 chromosomes, 53 being contributed from the female parent P.O.J. 2725 with a haploid egg, and 19 from *M. japonicus*, the male parent. Its chromosomal constitution as found in different cells at MI (Fig. 4 and Pl. I, Fig. 4) is given in Table 2.

TABLE 2. CHROMOSOMAL CONSTITUTION OF 33-84

Frequency	IV	III	II	I	Total
4			28	16	72
4			30	12	72
2			27	18	72
2		1	28	13	72
2		1	27	15	72
1	1	1	27	11	72
1			31	10	72
1		1	29	11	72
1	1		25	18	72
1			29	14	72
1	2		22	20	72
Total 20					

From the chromosomal constitution of the different cells at MI. it could be seen:

1. That the univalents varied from 10 to 20, would mean autosyndetic pairing of both chromosomes from P.O.J. 2725 and *M. japonicus*. It would mean that the 50 noble-cane chromosomes paired *inter se*, forming 25 pairs; and some of the *Miscanthus* chromosomes were also able to pair with each other. Perhaps some of the *Miscanthus* chromosomes were able to pair with four of the *S. spontaneum* chromosomes, coming from P.O.J. 2725, allosyndetically. As a result, many instances of unequal pairing were found (Fig. 12). Some of them were able to form interstitial chiasmata, while majority of them formed only terminal chiasmata signifying partial homology, only, between the ends of the pairing chromosomes. These unequal pairs, in general, disjoined precociously in metaphase.

2. Multivalents were found (Fig. 14 and 15) occassionally, indicating homology of the *Miscanthus* chromosomes with those chromosomes either of noble-cane, or of Glagah; for in P.O.J. 2725 no multivalents were found in the few cells studied.

3. Two bivalents linked together by a chromatic thread, as illustrated in Figure 13, were of frequent occurrence. Chains like this, multiple bivalents in a chain, and multiple chains, did not occur in line 33-84 as often as in P.O.J. 2725, or other noblecane varieties with twice the number of noblecane chromosomes. Text figure 30 of Moriya (6.) depicted the same thing. The significance of this will be discussed later.

4. Many of the bivalents formed a closed figure, others an open one. Efforts were made to determine the relative frequency of these types in the cells of a varying number of bivalents, so as to give some indiction of the identity of the chromosomes, but these were fruitless (Fig. 5 and 6). Nevertheless, the open types did disjoin precociously in the first metaphase and in the subsequent anaphase stages.

5. Some bivalents, like the one illustrated on the extreme left of Figure 6, were no other than two univalents: either of identical shape, or otherwise of unidentical

form held together at the centromere so as to form a cross. It seemed here that the lowest number of chiasmata was formed among these bivalents and their terminalization had taken place rather early and was complete. This would indicate that there was homology only in the region proximal to the centromere of the two pairing chromosomes.

6. The identity of the chromosomes was a big puzzle. In some diakinesis or metaphase figures of the carmine smear preparations, approximately 19 chromosomes either paired or single were found, which were banded and marked like those found in the smear preparations of the salivary gland chromosomes of *Drosophila*. In diakinesis, particularly, this type of chromosome was less condensed and occurred in juxtaposition, presumbly possessing residual attraction. In contrast to them, the other chromosomes were darkly stained and very regular in outline. This condition persisted until the metaphase stage. Unfortunately in many other preparations, such contrasting types were not found. Thus, the identity of the chromosomes, especially the sorting out of those belonging to *Miscanthus*, remains to be solved.

8. Congression of the univalents was much slower than that of the bivalents. Some never congressed: instead, they were included in the nearest polar group to which they happened to be located. Others did eventually congress to the equatorial plate, but were much delayed; as a result, they lagged behind in anaphase. Some did split, the half chromatids going to their respective poles. Others remained unsplit. In the second metaphase, non-congression of the univalents also occurred (Fig. 9), resulting in the formation of micronuclei in the tetrads (Fig. 11).

(b). LINE 33-85. Line 33-85 had a larger cane, very much like the so-called normal type of Moriya (6), but it had narrower leaves like those of line 33-84 (Table 7). It had 74 chromosomes, 55 of which were contibuted by P.O.J. 2725, and should be classified as the intermediate type. The chromosomal constitution of this line as found in different cells (Fig. 8 and Pl. I, Fig. 5) is given in Table 3.

TABLE 3. CHROMOSOMAL CONSTITUTION OF 33-85

Stage	Frequency	IV	III	II	I	Total
Metaphase	4			32	10	74
	1			24	26	74
	1			27	20	74
	1			28	18	74
	1	1	1	31	5	74
Diakinesis	1			26	22	74
	1			33	8	74
	Total 10					

From the ten cells analysed, the univalents varied from as low as 5 to as many as 26. Perhaps some precocious dividing of the loosely paired bivalents could be offered as an explanation for such a wide variation. This wide variation of the number of univalents would signify nearly complete autosyndesis of the *Miscanthus* chromosomes on the one hand, and on the other a complete failure. Multivalents did not occurr as frequently as in the other line 33-84. Except for these two minor differences besides the difference in chromosomal number, they behaved very much like the other line 33-84; so no additional remarks need be made.

(c). LINES 33-86, 33-94, 33-95, 33-96, and 33-98. These 5 lines were grouped together and designated the normal type. They were all characterized by having a large cane, wider leaves and a relatively high sugar content (Table 7). Outwardly they looked more like the female parent P.O.J. 2725. They all had, in fact, 126 somatic chromosomes, a result of the fertilization of the unreduced female gametes which contributed 107 chromosomes, and the reduced gametes of *M. japonicus,* which contributed 19. This is the process of "nobilization" (Brandes 2.). The chromosomal constitution of different cells as found in two of the lines studied at first metaphase (Fig. 17 and Pl. I, Fig. 6) is given in Table 4.

TABLE 4. CHROMOSOMAL CONSTITUTION OF 33-86 AND 33-98

	Frequency	IV	III	II	I	Total
Line 33-86	2			53	20	126
	1			55	16	126
Line 33-98	4			58	10	126
	2			55	16	126
	2			59	8	126
	1			52	22	126
	1			56	14	126
	1			49	28	126
	1	1		50	22	126
Total	15					

From the study of P.O.J. 2725, it was learned that the univalents varied from 9-13. In these lines, as few as eight univalents were found in one cell. This would signify that autosyndetic pairing amongst the 19 chromosomes of *Miscanthus* had been complete, or that some of them had paired with the partially homologous chromosomes of P.O.J.2725 which existed originally as univalents; and were possibly of Glagah origin. Cells with univalents as numerous as 28 would suggest that there had been no autosyndesis of *Miscanthus* chromosomes *inter se,* nor with the univalents of P.O.J.2725. It must be born in mind that precociously dividing bivalents of the "open" figure type would confuse the situation immensely.

The infrequent occurrence of multivalents deserves some consideration here. In the fifteen cells examined, only one tetravalent was encountered. This was in great contrast to the frequent occurrence of tetra- and tri valents in the cells of lines 33-84 and 33-85. Perhaps this is because the chromosomes of the reduced gametes of noblecane, in the case of 33-84 and 33-85, would have a better chance of forming multivalents with the partially homologous chromosomes of *Miscanthus,* than when they are more or less satisfied by their own original homologues so as to form bivalents exclusively, as in the present case. In order to test this hypothesis it is essential that methods of sampling should be adequate. As was uaual, lagging univalents were found in the first telophase (Fig. 18), and micronuclei were again occaiconally found in tetrads, but most of the tetrads lacked them, particularly in line 33-98.

(d) Line 46-43. From backcrossing the male sterile line 33-84 (2n=72) by *S. spontaneum* L. (2n=112), we obtained one tri-hybrid seedling *(S. officinarum, M. japonicus* and *S. spontaneum).* This had 128 chromosomes, evidently a result of the

fertilization of a diploid female gamete with 72 chromosomes, by a haploid male gamete with 56 chromosomes. In diakinesis, (Fig.19) those chromosomes apparently belonging to *Miscanthus* were in juxtaposition. They appeared to be less condensed and mostly unpaired. It is a noteworthy fact that there were more than twenty pairs of bivalents in the form of a cross. These bivalents were very loosely paired, being attached only near centromere region. Probably only a few chiasmata were formed and these showed an early and complete terminalization. There were only a few of such cross shaped bivalents found in the line 33-84. Thus, these additional ones might well be attributed to the contribution from S. *spontaneum*, the male parent. *S. spontaneum* was found to have 56 bivalents at MI (Fig.16), though a few of them were of the open type that were liable to disjoin precociously at MI, and subsequently. When its haploid gamete of 56 chromosomes was introduced into the hybrid, autosyndesis resulted but pairing was rather loose, indicating only partial homology. The chromosomal constitution of this tri hybrid as found in different cells (Fig.20 and Pl. I, Fig. 7) is given in Table 5.

TABLE 5. CHROMOSOMAL CONSTITUTION OF 46-43

Frequency	IV	III	II	I	Total
2	1		56	12	128
1			52	24	128
1		1	56	13	128
1	2		55	10	128
1	2		52	16	128
1		1	58	9	128
1	1		55	14	128
1	2	2	50	14	128
1			55	18	128
1			56	16	128
Total	11				

It may be recalled that the number of univalents varied from 10-20 in the line 33-84. In this tri-hybrid, the chromosomes of the line 33-84 were maintained unchanged, with only the addition of 56 chromosomes contributed by *S. spontaneum*. Nevertheless, its number of univalents showed the slightly wider variation of 9-24. This would mean that autosyndetic pairing of the 56 chromosomes coming from *S. spontaneum* was nearly complete. Again, multivalents were found to be rather high in line 33-84, but in this tri-hybrid, they were even more numerous. In one of the cells, two tetra- and two tri-valents were found simultaneously. Attention should be drawn to the fact that there were several chromosomes which were originally of *S. spontaneum* origin (donation from Kassoer). These, perhaps, would form multivalents with those of Glagah. However, since the chromosomes of Glagah did not form any multivalent as could be observed, it would invalidate this supposition. It would be more likely therefore, that the multivalent were formed between chromosomes of *S. officinarum* and *S. spontaneum* or those of *S. spontaneum* and *Miscanthus*. In fact, one of the cells found in Kassoer at MI,had $4^{IV}58^{II}6^{I}$. From this is would seem most probably that multivalent formation existed rather frequently between chromosomes of *S. officinarum* and *S. spontaneum*.

Some of the multivalents are shown in Figures 23 and 24. There were lagging univalents as usual (Fig.21) in the first telophase, and micronuclei in the tetrad (Fig.22).

Pollen fertility of different hybrid lines

Having examined the chromosomal constitution of the different parental and hybrid lines, it is of interest to investigate their fertility. Unfortunately, pollen samples for several of the lines were not available at the time of collection. Pollen grains from those plants just about to shed their pollen, were preserved in 95% alcohol and stained with potassium iodide solution. Those grains which stained bluish-black, signifying starch storage, were classed as fertile. The result of these studies is shown in Table 6.

TABLE 6. POLLEN FERTILITY OF DIFFERENT LINES

Line	2n	% of fertile grains	Total
P.O.J.2725	107	2.33	985
33-84	72	11.31	1,414
33-85	74	5.96	1,359
33-86	126	8.04	696
33-94	126	6.23	738
33-95	126	2.68	819
33-98	126	38.05	1,222

P.O.J.2725 was male-sterile. Most probably this was genetically determined, and not due to chromosomal aberration, for its sister lines such as P.O.J.2714, 2722, 2875, 2878, 2883, were highly pollen-fertile in spite of the existence of numerous univalents (unpublished data). This genetically controlled pollen sterility persisted even with the addition of 19 *Miscanthus* chromosomes in the normal type of hybrids such as 33-86, 33-94, etc. Again, it persisted also in the intermediate types of hybrids such as 33-84 and 33-85, even though a "single dose" was involved. Line 33-98 was moderately fertile, thus differing from other lines of the normal type which have practically the same chromosomal constitution and genetical make-up. Perhaps the vigour of the plants, or sampling errors might be offered in explanation for this wide difference. Nevertheless, it needs further verification.

Since the anthers of none of these lines dehisced, they were not used as male parents. The fertility of the eggs was not determined but it would seem to be very low, because very few seedlings were obtained from them whenever they were used as the female parent.

Morphological and physiological characters of the different lines

The data were not complete. They showed, however, that the hybrids of the normal type have larger canes, wider leaves, smaller number of tillers, and higher sugar content than the hybrids of the intermediate type. Among the lines in the normal type hybrid, there is a great variation both in morphology and sugar content in spite of the fact that they have exactly the same genetical make-up. In general, these lines resemble more closely the female parent P.O.J.2725. On the other hand, the intermediate type lines are a blend of the two parents. This, of course, is in accord with the cytological findings just described.

TABLE 7. MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERS OF THE DIFFERENT LINES

Line	2n	Symbol	Height of plant in cm.	Width of cane radius in mm.	Width of leaves in cm.	Average no. of tillers	Sugar content in %
P.O.J.2725	107	20*					15.00 (brix)
Glagah	112	2S	148.6	0.50	1.60	6.0	
M. japonicus	38	2M					0.00
33-84	72	10+1M	141.6	8.92	4.10	3.0	11.33 (brix)
33-85	74	10+1M	229.0	14.00	4.20	2.6	6.00
33-86	126	20+1M	227.0	14.00	5.70	1.5	8.60
33-94	126	20+1M	175.0	12.50	4.90	2.0	10.75
33-95	126	20+1M	162.6	19.00	6.90	1.0	15.00 (brix)
33-96	126	20+1M	214.0	16.00	6.70	1.2	7.75
33-98	126	20+1M	198.0	16.00	6.20	1.6	14.80
46-43	128						

*"O", "S", and "M", represent *S. officinarum*, *S. spontaneum* and *Miscanthus* respectively. "2 0" represents the total somatic chromosome number, "1 0" its reduced number.

DISCUSSION

In view of the fact that one of the wild relatives of *S. officinarum*, *S. munja* Roxb. from Karnal in India, as reported by Singh (Review from Moriya, 7. though Janaki-Ammal 4. changed it to *Erianthus ravennae*) has 10 chromosomes as the haploid number, possibly the basic number for the genus *Saccharum* is 10, as in the genera *Sorghum, Zea, Erianthus,* and *Imperata* which can be crossed easily with noblecane. However, in *S. spontaneum,* the number varies. Some do have a multiple of 10, but in others it is a multiple of 8. Accordingly, it seems that 8 can not be excluded as a possible basic number for this genus. Whatever the basic number may be, it is very important to future work that it should be unequivocally determined. Be it assumed therefore, for convenience, that two species of *Saccharum* having 10 chromosomes but of two unlike genomic constitutions A and B, are crossed in nature, and the chromosomes are doubled to form an amphidiploid AABB of 40 chromosomes. Owing to the complementary action of the genes brought in from the original species, the sugar content of the amphidiploid is greatly increased. Similarly, the size of the cane is greatly increased. In contrast, the original species may have a very low sugar content, or none whatsoever, and it may also have slender canes. Perhaps by a second doubling in nature, this amphidiploid AABB become an octaploid with 80 chromosomes. The final outcome is a further increase in the sugar content. This probably represents the prototype of the varieties of noblecane which have developed later, consequent on this initial type being selected and cultivated by the natives of the South Sea Island, where the wild species are indigenous. Randolph and Hand (8) accounted for an increase of 40 percent in the content of carotenoid pigments in yellow corn meal, on the assumption that genes for yellow endosperm exerted a cumulative effect following chromosomal doubling 2n→4n. The higher crude protein content of the tetraploid stover as compared with its corresponding diploid was accompanied by a correspondingly lower content of crude fibre and cellulose (Ellis, *et al*, 3). Barr and Newcomer (1) reported that tetraploid cabbage contained 36.48 percent more sugar, 23.86 percent more ascorbic acid, and 32.62 percent more colloidal nitrogen than diploid

cabbage, but the diploid had about 14 percent more soluble nitrogen than the tetraploid. If the cumulative gene action hypothesis of Randolph is correct, it would be applicable equally to the sugar cane. Its octaploids, the noblecane varieties, theoretically ought to have a higher sugar content than the allotetraploid from which they are derived. In this, the P.O.J.2725 × *Miscanthus* cross, substantiates this hypothesis. Lines such as 33-86, 33 94 etc. with the full chromosomal complement of P.O.J.2725 (107), in addition to the 19 chromosomes contributed from *Miscanthus,* have a comparatively higher sugar content (Table 7) than those lines such as 33-84 and 33-85, with reduced gametes (P.O.J.2725 and *Miscanthus*). The process of "noblization" in sugarcane breeding, to be discussed later, will further substantiate this hypothesis.

This working hypothesis for the possible origin would be groundless, should the origin of the allotetraploid not be found. If this original species with 10 chromosomes exists, then when it is artificially crossed, and the chromosomes doubled and redoubled, we might obtain an artificially synthetic noblecane. Should this be possible, a final solution of the phylogenetical development of sugareane would be achieved. A coöperative effort from all the sugarcane breeders would be necessary for bringing this about.

From the above hypothesis, it follows, that the 80 chromosome noblecane varieties are strictly "tetraploid" after the doubling of the chromosomes of the original allotetraploid with 40 chromosomes. Its genomatic symbol is AAAABBBB. Instead of forming multivalents, forty bivalents are invariably found. Lilienfeld (1936) found strictly bivalent in her autohexaploid *Fragaria elator* and Shimatomai (1931, and 1933) likewise found bivalent formation in his polyploids of Chrysanthemum (see literature citation of Moriya, 6). In P.O.J.2725, while two successive "noblizations" have taken place, its genomatic symbol may be represented by AAAAABBBBB+7. Forty of the A genom form 20 bivalents, leaving the other 10 remaining chromosomes to pair among themselves A_1A_2, A_3A_4 etc. Chromosomes of the B genom behave in the same way. This intragenomatic pairing is comparable to the pairing in the haploids of other plants. The behaviour is, however, not altogether constant. Chromosomes of the A genom may pair with those from the genom B, or with those of *S. spontaneum,* when opportunity for pairing with their own homelogues does not exist. Judging from the picture we obtained of the chromosomal constitution of P.O.J.2725, the number of bivalents ranges from 42-49 but it was never 50; this adds some support to the hypothesis just offered.

The chromatic threads that link bivalents to form chains may indicate some residual attraction among the bivalents from like genoms. These chromatic threads persist from diakinesis to anaphase. Furthermore, chains of 5 or 6 bivalents were observed in some related lines of P.O.J.2725. Indeed, the chains are so numerous and entangled in metaphase, and even in anaphase, in some of the lines, that counting is difficult or sometimes impossible. In lines such as 33-84, and 33-85, with reduced gametes of P.O.J.2725, chains like this are rarely found. Even if they are present usually two, but never more than tree bivalents are found to be linked together. This seems to be in accordance with the genomatic analysis just given.

In regard to autosyndetic pairing of the chromosomes of *Miscanthus* in the various hybrid lines, in some cells, this pairing seems to be complete; in other cells there is no

pairing. On the other hand, autosyndesis of the 56 chromosomes contributed by Glagah seems to be complete in the hybrid 46-63. Very much like noblecane, *S. spontaneum* is a higher order polyploid with 112 chromosomes forming 56 bivalents. When it is used as a male parent, its 56 chromosomes pair autosyndetically in the hybrid. Judging from the numerous multivalents formed in the hybrid 46-43, the chromosomes of *S. spontaneum* and those of *S. spontaneum* are rather closely related. Li and Tu (5) hypothesized the unpairing of the chromosomes contributed by the male parent in the original cross of the *Triticum-Aegilops* amphidiploid, to be due to unsuccessful competition for the nucleic acid. The almost complete autosyndesis of Glagah chromosomes in the hybrid would therefore indicate harmonious orientation in a foreign cytoplasm. Conversely, great variation in the degree of autosyndesis of *Miscanthus* chromosomes in the hybrid may mean unsuccessful competition for nucleic acid. This, of course, does not exclude other possible explanations.

"Noblization" of sugarcane is first observed in the natural hybrid, Kassoer, noblecane and *S. spontaneum*. Since its first occurrence, "noblization" has been used repeatedly in sugar cane breeding at various stations. Moriya (6) found 13.5 percent of "noblized" plants, the so-called normal type, in his sugarcane-sorghum hybrids. The process of "noblization" is sometimes erroneously assumed to be the result of a cross with sugar cane and other wild species (6). This is not true. In fact, "noblization" takes place in varieties of noblecane too. At least two instances of this have been found (unpublished data). Probably the production of unreduced eggs, having a higher order of polyploidy, is of frequent occurrence in the sugar cane. Bremer (review of Moriya 6.) described this phenomenon to be the result of the splitting of the reduced material chromosomes, which occurs just at the time of fertilization. There may be other explanations, some of which are proposed below.

1. Formation of the restitution nucleus in mitosis prior to megasporogenesis may produce eggs with an unreduced number of chromosomes. In the course of study of microsporogensis, a number of P.M.C., that have approximately twice the number of chromosomes are observed. But their frequency is too low to account for the high frequency, 13.5%, found in sugarcane-sorghum hybrid.

2. Omission of the second division in meiotic mitosis in megasporogenesis can produce eggs with the unreduced number of chromosomes.

3. Triple fusion of a sperm with the egg and one of the synergids, or with the two fused synergids will give the same result.

A conclusion cannot be reached, however, until a careful study of megasporogensis of such lines as P.O.J.2725 and the like is carried out.

Should the cumulative gene action hypothesis be correct, the sugar content of sugarcane varieties could be increased almost indefinitely with increasing number of chromosomes following successive "noblization." This, however, is possible but not probable judging from the results obtained so far. In the list of sugarcane varieties given by Moriya (6) none of them has a somatic chromosomal number higher than 166. It is very likely, that there is a limit set for the increase of the number of chromosomes beyond a balance of nucleo-cytoplasmic ratio. Further increase beyond this limit may be extremely detrimental to the plant, so as to make it altogether non-viable or else, the growth of the plant is so stunted as to be overlooked by the plant

breeder. Nevertheless, even with this unfortunate limitation, the plant breeders can avail themselves of this knowledge to carry out a proper manipulation of the process of "noblization;" the aim being to bring together as many noblecane chromosomes in the hybrid as possible, thus taking advantage of the cumulative gene effects for sugar content without distorting the nucleo-cytoplasmic ratio. This, perhaps, will carry the breeders closer to their final destination than if they should believe dogmatically in the wonder that might arise from the augmenting of the chromosome number in a line from repeated "noblization."

SUMMARY

Crossing P.O.J.2725 with *M. japonicus* gives two types of seedling:

1. Intermediate type: This was characterized by a slender cane, narrower leaves, and a lower sugar content. It had the reduced gametes of both parents.

2. Normal type: This was characterized by a larger cane, wider leaves and a higher sugar content. In general, it resembled the female parent very closely. It had the unreduced gamete from the female parent and the reduced gamete from the male.

One of the intermediate types was crossed with *S. spontaneum*, and a tri-hybrid was obtained. It contained the unreduced female gamete and the reduced male gamete.

Meiosis was studied for all the parents as well as the hybrid lines.

In *S. spontaneum* and *S. officinarum* both with a higher order of polyploidy, had chromosomes mostly, if not exclusively bivalents; rarely, a few multivalents were found. Sometimes, however, pseudo-multivalents were formed by having chromatic threads joining bivalents together to form chains in prophase, metaphase, and even persisted to anaphase in the first meiotic mitosis. In the hybrids involving reduced chromosomes, autosyndetic pairing resulted. Chromosomes of *Miscanthus* behaved similarly, but were inconsistant. Some pairing was observed between chromosomes of different parents in a hybrid as manifested by multivalents and unequally paired chromosomes.

Noblecane varieties were hypothesized to be derived from the doubling of the amphidiploid which would be formed by the natural hybridization of two species of *Saccharum*, or related genera, each with a basic number of 10 chromosomes, but of unlike genomatic constitution.

"Noblization" was defined to be the union of the unreduced noblecane gamete used as the female parent, with any reduced or unreduced male gamete from noblecane, wild species of *Saccharum*, or other related genera.

The process of "noblization" could not be indefinite, because the increment of chromosomes would be limited by the nucleo-cytoplasmic ratio.

EXPLANATION OF PLATE I

Fig. 1. Spikes of parents and hybrid 33-84.
Fig. 2. Canes of parents and hybrid 33-84.
Fig. 3. Young seedling of 46-43.
Fig. 4. Metaphase of 33-84, showing bivalents and univalents.
Fig. 5. Diakinesis of 33-85, showing the darker stained and unpaired *Miscanthus* chromosomes.
Fig. 6. Metaphase of 33-98, showing bivalents and univalents.
Fig. 7. Anaphase of 46-43, showing 128 chromosomes.

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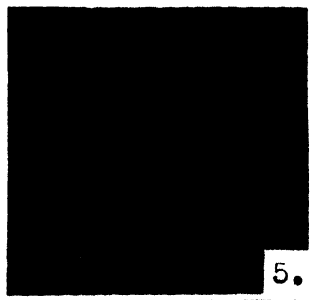

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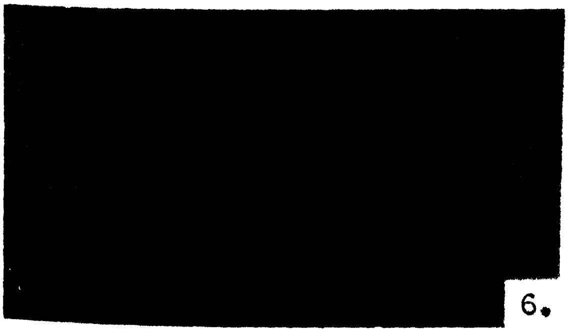

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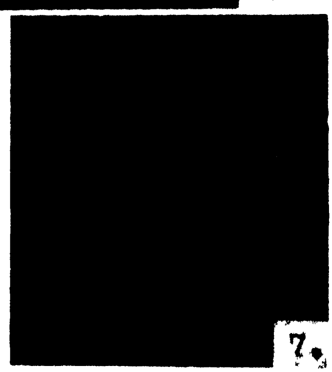


7.

EXPLANATION OF TEXT FIGURES

Fig. 1. P.O.J.2725. MI. showing $48^{II}11^{I}=107$. Bivalents are in black and univalents outlined only

Fig. 2. P.O.J.2725. TI. showing lagging univalents that divide on the equatorial plate.

Fig. 3. P.O.J.2725. TII. showing lagging univalents (cell wall is not shown).

Fig. 4. 33-84 MI. showing $28^{II}+16^{I}=72$.

Fig. 5. 33-84 idiogram of the chromosomes $1^{IV}+25^{II}+18^{I}$. At least 10 bivalents are open shaped.

Fig. 6. 33-84 same as 3 showing $30^{II}+12^{I}$. There are at least 7 bivalents that are open shaped.

Fig. 7. 33-84 AI. showing laggards.

Fig. 8. 33-85 MI. showing $32^{II}+10^{I}=74$.

Fig. 9. 33-85 MII. showing scattering univalents.

Fig. 10. 33-85 TII. showing laggards.

Fig. 11. 33-85 Tetrad (cell wall not shown with micronuclei.

Fig. 12. Unequal pairing of bivalents found in different cells. The four bivalents at the bottom are from 33-84 and the rest from 33-85.

Fig. 13. Two bivalents joined together by chromatic thread forming pseudotetravalent as found in 33-84.

Fig. 14. Trivalents.

Fig. 15. Tetravalent found in 33-85.

Fig. 16. *Sp spontaneum* L. var. Glagah, $MI=56^{II}$ used as one of the parents.

Fig. 17. 33-98 MI. showing 58^{II} $10^{I}=126$.

Fig. 18. 33-98 TI. showing lagging univalents.

Fig. 19. 46-43 Diakinesis showing 55^{II} $18^{I}=128$.

Fig. 20. 46-43 MI. showing 1^{IV} 55^{II} $14^{I}=128$.

Fig. 21. 46-43 TI. showing lagging univalents.

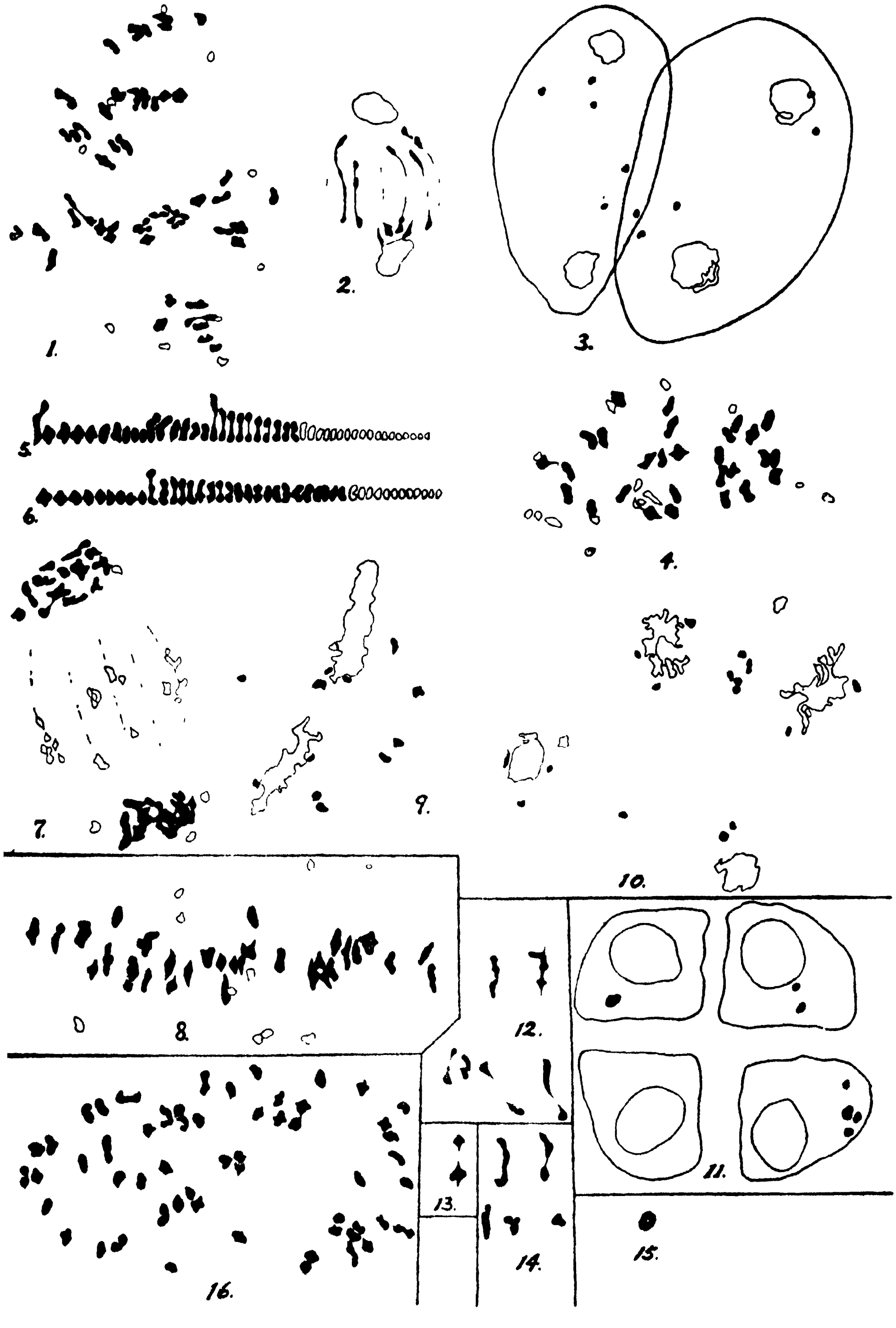
Fig. 22. 46-43 Tetrad (cell wall not shown) showing micronuclei.

Fig. 23. 46-43 Trivalent.

Fig. 24. 46-43 Tetravalents found in different cells. The tetravalent found at the rightmost seems to belong to *M. japonicus.*

Fig. 25. Metaphase in root tip cells of *Miscanthus japonicus* showing 38 chromosomes.

(All figures 750x.)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THE MARINE MYXOPHYCEAE IN THE VICINITY OF FRIDAY HARBOR, WASHINGTON

CHIN-CHIH JAO

During the period from August to December, 1935, the writer had the opportunity to work on marine algae in the Oceanographic Laboratories of the University of Washington on the San Juan Island of the San Juan Archipelago, Washington. As no report especially on the marine Myxophyceae of these Islands had been published, Professor George G. Rigg of the Laboratories suggested to the writer to prepare an usable manual on this subject for future investigators working on the local flora of this district. After a four-month collecting, a large number of specimens belonging to different classes of algae has been obtained from many different localities. Among them, the Myxophyceae from the San Juan, Brown, Turn, MaConnell, Canoe, Bell, and Shaw Islands are especially prepared for this report. In 1936, the writer brought them to China and got through the identification work of these specimens some months after the Japanese invasion into North China on July 7, 1937. Due to difficulties of printing in the war time, publication of this investigation has been withheld for more than ten years until now.

As we know that the vicinity of Friday Harbor is noted for the abundance and variety of its marine flora, especially the Phaeophyceae and Rhodophyceae; but, after making an extensive collection and careful study, the writer found that the Myxophyceae distributed in this region are not in such a condition. Among the species of Myxophyceae, only a few members, such as *Gloeocapsa crepidinum*, *Oscillatoria Bonnemaisonii*, *Lyngbya aestuarii*, *Symploca funicularis*, and *Calothrix crustacea*, are rather widely and comparatively abundantly distributed in this region; the others are, however, either quite scattered or fairly abundant only at certain spots. The low productivity of this group of algae in this region is undoubtedly due to the influence of rather low water-temperature throughout the year.

Our knowledge on the marine Myxophyceae of the Washington State is very scanty. As listed in Setchell and Gardner's "The Marine Algae of the Pacific Coast of North America, Part 1. Myxophyceae" (Univ. Calif. Publ. Bot. 8: 1—138, pl. 1—9. 1919), there are only twenty nine species, one variety, and one form recorded from various localities in this State. They are: *Dermocarpa fucicola*, *Spirulina major*, *Oscillatoria Bonnemaisonii*, *Lyngbya aestuarii*, *L. semiplena*, *Isactis plana* var. *plana*, *Microcoleus chthonoplastes*, *M. tenerrimus*, *Calothrix scopulorum*, *C. pulvinata*, and *C. rectangularis* from Puget Sound; *Gomphosphaeria aponina*, *Dermocarpa sphaerica*, *D. protea*, *Spirulina subsalsa* f. *oceanica*, *Oscillatoria limosa*, *O. nigro-viridis*, *O. amphibia*, *O. chalybea*, *Symploca hydnoides*, and *Calothrix consociata* from Whidby Island; *Placoma violacea*, *Dichothrix seriata*, and *Rivularia mamillata* from Cape Flattery; *Dichothrix minima* from Chruckanut Quarry; *Pleurocapsa fuliginosa* from Seattle; *Calothrix Contarenii* from Southern Washington; *Nostoc Linckia* from Port Townsend; *Chroococcus turgidus* and *Rivularia Biasolettiana* mentioned to be distributed from Alaska to California; and *Calothrix crustacea* to be distributed from Washington to California. Among these species, only *Placoma violacea*, *Pleurocapsa fuliginosa*, *Isactis plana* var. *plana*, *Calothrix consociata*, *C. pulvinata*, *C. rectangularis*, *Dichothrix seriata*,

D. minima, Rivularia Biasolettiana, and *R. mamillata* were not found by the writer in the San Juan Archipelago.

In the present report, fifty-two species, one variety, and one form of the Myxophyceae are listed. Among them, *Synechococcus marinus, Hyella purpurea, Chamaesiphon Pylaiellae, Phormidium spirale, P. nostochoides, Lyngbya Amphiroae, Hydrocoleus mirificus, Anabaena Vaucheriae,* and *Microchaete Cladophorae* are described as new to science. *Microcystis pallida, Gloeocapsa atrata, Chroococcus minutus, Merismopedia convoluta, Xenococcus pyriformis, Pleurocapsa crepidinum, Hyella caespitosa* var. *nitida, Dermocarpa sphaeroidea, D. violacea, Oscillatoria Corallinae, O. laetevirens, O. subuliformis, O. brevis, Phormidium tenuis, P. uncinatum, Lyngbya Nordgardhii, L. gracilis, Symploca funicularis, S. aeruginosa, Anabaena torulosa, Microchaete vitiensis, Calothrix confervicola, C. prolifera, Rivularia atra,* and *Plectonema Battersii* are new to the Washington State.

Type specimens of the new algae described in this paper are kept in the Herbarium of the Institute of Botany, Academia Sinica, Shanghai.

The writer wishes to express his gratitute to Dr. Thomas G. Tompson, Director of the Oceanographic Laboratories of the University of Washington, and to Professor George B. Rigg for their assistance in the execution of this work, and to Dr. Lyman D. Phifer and other staff members for help in collecting specimens.

CHROOCOCCALES

CHROOCOCCACEAE

MICROCYSTIS KUETZ., 1933

1. Colonial tegument with a firm surface layer; cells oblong-ellipsoid, 3.0—3.6 μ in diameter, 4—7 μ long .. *M. elabens*
1. Colonial tegument without a firm surface layer; cells globose or subobovoid 4.0—5.5 μ in diameter *M. pallida*

MICROCYSTIS ELABENS (Bréb.) Kuetz., Tab. phyc. 1: 6, pl. 8. 1945—49; Forti, in De Toni's Syll. Alg. 5: 88. 1907.

Polycystis elabens Kuetz., Sp. Alg. 210. 1894.

Anacystis elabens (Kuetz.) Setch. et Gardn., Univ. Calif. Publ. Bot. 6: 455, pl. 38, figs. 6, 7. 1918.

San Juan Island: Deiner Point, epiphytic on *Rhizoclonium riparium* in the upper littoral belt, fairly common, but not abundant; Mosquito Pass, Westcott, and Jekyll Lagoon, scattered among other algae on floating logs, scarce.

The colonies of this species found in these stations are typical in form and structure. The young ones are nearly spherical or oblong. The older ones are mostly much flattened and irregularly lobed. Each colony is surrounded by a common gelatinous tegument and constantly containing a number of daughter colonies each surrounded by its own tegument. The tegument is moderately thin and firm. The cells are 3.0—3.5 μ in diameter, 4—7 μ long, densely aggregated, and sometimes with a more or less distinct individual sheath.

MICROCYSTIS PALLIDA (Farlow) Lemm., Krypt. Fl. Mark Brandenb. 3: 77. 1907.

San Juan Island: Mosquito Pass, scattered among other blue green algae on logs in the uppermost littoral belt, scarce.

The colonies of the local form are irregular in outline, up to 500 μ wide, and sometimes containing several daughter colonies each surrounded by its own confluent tegument. The colonial tegument is moderately thick and gelatinous, but does not show a firm surface layer. The cells are globose or subobovoid, 4.0—5.5 μ in diameter, and with bluish green and finely granular contents.

This species differs from *M. litoralis* (Hansg.) Forti chiefly in having larger cells and indistinctly limited colonial tegument.

GLOEOCAPSA Kuetz., 1943

GLOEOCAPSA ATRATA (Turp.) Kuetz., Tab. phyc. 1: pl. 21, fig. 4. 1845—49.

San Juan Island: Westcott, on rotten logs in the uppermost littoral belt, scarce; Deiner Point, scattered among *Enteromorpha torta* on damp ground a little above or below the high tide mark, scarce.

The mass of colonies usually form gelatinous, thin, pale blue green, and irregularly expanded strata attached to the substratum. The cells are either single or in families of two or four, 3.5—5.0 μ in diameter, and with a moderetely thick, colorless or bluish, and often distinctly lamellose individual sheath. Their contents are finely granular and pale blue green.

CHROOCOCCUS Naeg., 1849.

1. Cells 4—7 μ in diameter; sheaths not lamellose ... *C. minutus*
1. Cells 13—40 μ in diameter; sheaths distinctly lamellose ... *C. turgidus*

CHROOCOCCUS MINUTUS (Kuetz.) Naeg., Gatt. einzell. Alg. 46. 1849.

San Juan Island: a cove near Deiner Point, scattered among other blue green algae on rotten logs in the uppermost littoral belt, scarce.

Shaw Island: a salt marsh at Neck Point, on rotten logs, fairly scarce.

The specimens collected in these Islands are quite similar to one another. The cells are 4—7 μ in diameter, and with a sheath of about 2 μ in thickness. In size, they are a little smaller than the typical form.

CHROOCOCCUS TURGIDUS (Kuetz.) Naeg., Gatt. einzell. Alg. 46. 1948.

San Juan Island: Jekyll Lagoon, Mosquito Pass, Deiner Point, and Friday Harbor, scattered among other algae in the uppermost littoral belt, scarce.

Shaw Island: salt marshes at Pt. Neck, on rotten logs, scarce.

Brown Island: growing on *Fucus evanescens* in the upper littoral region, scarce.

This species seems to be very common but always quite scattered in the vicinity of Friday Harbor. The cells of the local plant vary from 13 to 40 μ in size, but often 20—30 μ in diameter. The unicellular individuals are very rare; most of them two or four-celled.

GOMPHOSPHAERIA Kuetz., 1836

GOMPHOSPHAERIA APONINA Kuetz., Alg. exsicc. Dec. 16, No. 151. 1836.

San Juan Island: Mosquito Pass, Angyle Lagoon, and Jekyll Lagoon, floating among other algae, rare.

Shaw Island: Neck Point, among other algae in marshes, rare.

Merismopedia Meyen, 1839

Merismopedia convoluta Bréb. in Kuetz., Sp. Alg. 472. 1849.

San Juan Island: Westcott Creak, scattered among other filamentous algae in salt marshes, scarce.

A single colony of the local plant is composed of 16—64 cells and with a thickness of 7.0—8.5 μ. The cells are closely approximated to one another, 3.5—5.0 μ in diameter, and 6.5—8.5 μ long. In the typical form of this species, the colonies are usually composed of numerous cells and reach 1—4 mm. broad. These facts are, however, not true in the local form.

Synechococcus Naeg., 1849

Synechococcus marinus, sp. nov. (Fig. 1, *f*)

S. inter ceteras algas sparsus; cellulis cylindraceo-obovoideis, singulis vel geminatis, 6.5—8.5 μ latis, 9—11 μ longis; membrana tenuissima; contentu pallide olivaceo, minute granuloso.

San Juan Island: Jekyll Lagoon, scattered among other algae on floating rogs, scarce. *Jao 1267* (type).

The cells of this species are much larger than those of *S. curtus* Setch., which is the only known marine species of this genus described from California coast. It should also be compared with *S. aeruginosus* Naeg., a freshwater species, but differs from the latter in having smaller dimensions and different shape of cells.

CHAMAESIPHONALES

PLEUROCAPSACEAE

Xenococcus Thur., 1875

Xenococcus pyriformis Setch. et Gardn., Univ. Calif. Publ. Bot. 6: 463, pl. 39, fig. 12. 1918.

San Juan Island: False Bay, epiphytic on *Pterosiphonia bipennata* in the lower littoral belt, scarce.

Turn Island: epiphytic on *Odonthalia Lyallii* in the lower littoral belt, scarce.

Brown Island: epiphytic on *Plocamiun tenue* in the upper littoral belt, scarce.

This species was described by Setchell and Gardner from Cape Arago, Oregon, in 1918 (loc. cit.), and was also recorded by Frémy from the Danish West Indies in 1939 (Dansk Bot. Ark. 9: 9. 1939), but has not been rediscovered from North America since 1918. The present specimens referred to this species are fairly typical, especially the shape and dimensions of their vegetative cells. Their mature sporangia are sometimes up to 23 μ in diameter and contain endospores with a diameter from 1.5 to 3.5 μ.

Pleurocapsa Thur., 1885

Pleurocapsa crepidinum Collins, Rhodora 3: 136. 1901; Geitler, in Rabenhorst's Krypt.-Fl. 14: 355, figs. 188 a, b. 1932.

This species was described by Collins from Otter Creek, Mount Desert, Maine, in 1901, and was rediscovered by Farlow from Magnolia Point, Massachusetts, in 1903,

but has not since been recorded again from other stations. Collins did not give the drawings for this species in his paper and described it not detailed enough (loc. cit.). The identification of the present material is based upon Geitler's diagnosis and drawings taken from the specimens of this species in Phyc. Bor.-Amer. No. 1157 (loc. cit.). Apart from having vegetative cells not more than 13 μ in diameter, the present material has characteristics same as those given by Geitler.

HYELLA Born. et Flah., 1888

1. Horizontal filaments usually composed of a single or sometimes two rows of cells; cells 6.5—15.5 μ in diameter .... *H. purpurea*
1. Horizontal filaments usually composed of more than two rows of cells; cells only 2—5 μ in diameter .... *H. caespitosa* var. *nitida*

HYELLA PURPUREA, sp. nov. (Fig. 1, *b*)

H. thallis in conchis penetrantibus, laete purpureis; filamentis primariis horizontalibus, irregulariter ramosis, intricatis, secundariis erectis, sparse ramosis aut simplicibus; cellulis filamentorun horizontalium eiusdem filamentae variantibus forma ac magnitudine, subglobosis, subobovoideis, irregulariter angularibus, interdum irregulariter plus minusve tumidis, plerumque uni- vel interdum bi-seriatis, 6.5—15.5 μ latis, 6.5—17.0 μ longis, illis filamentorum erectorum elongatis, uniseriatis, 6.5—8.5 μ latis, longitudine usque ad 68 μ, tegumento subgelatinoso, crasso, homogeneo, contentu minute granuloso et laete purpureo; endosporangiis e cellulis intercalaribus vel terminalibus filamentorum horizontalium transformatis, cellulis vegetativis saepius majoribus, 11—20 μ latis, 7—16 μ longis; endosporis 4—32 in endosporangio, globosis, 2.0—2.5 μ latis.

San Juan Island: Dredged at a depth of 5—10 fathoms off Griffin Bay, growing in emptied shells, fairly common. *Jao: 1280* (TYPE).

Canoe Island: Dredged at a depth of 5—10 fathoms off the Island, growing in emptied shells, fairly common.

This species differs from *H. caespitosa* Born. et Flah. and *H. Balani* Lehm. in having bright purple cell contents, horizontal filaments mostly composed of a single row of cells, and endosporangia usually seriate.

HYELLA CAESPITOSA Born. et Flah. var. NITIDA Batters, Journ. Bot. 34: 385. 1896.

Associated with the preceding species, fairly scarce.

This variety is distinguished from its type by the purplish-pink cell contents, the much branched thallus, the more slender filaments, and the endosporangia formed serially. These characteristics are quite distinct shown in the present material. No measurements of this variety were given by Batters (loc. cit.). Base upon the writer's material, its dimensions are: cells of the horizontal filaments 2—5 μ in diameter and long; those of the erect filaments 5—7 μ in diameter and 20—120 μ long.

DERMOCARPACEAE

DERMOCARPA Crouan, 1858

1. Cells spherical or nearly so 2
1. Cells distinctly elongated 3
2. Mature vegetative cells up to 34 μ in diameter .... *D. sphaeroides*
2. Mature vegetative cells up to 16 μ in diameter .... *D. sphaerica*

3. Mature vegetative cells up to 120 μ long ... *D. protea*
3. Mature vegetative cells not more than 60 μ long ... 4
4. Cells much narrowed below into a stipe-like portion; cell contents dark violet brown ... *D. fucicola*
4. Cells not narrowed below into a stipe-like portion; cell contents rose red ... *D. violacea*

DERMOCARPA SPHAERICA Setch. et Gardn., Univ. Calif. Publ. Bot. 6: 457, pl. 39, fig. 14. 1918.

Shaw Island: Growing on *Lyngbya aestuarii* in a salt marsh near Neck Point, scarce.

DERMOCARPA SPHAEROIDEA Setch. et Gardn., Univ. Calif. Publ. Bot. 6: 440, pl. 35, fig. 7, 1918.

San Juan Island: Deiner Point, epiphytic on other algae in the upper littoral belt or rarely on floating logs, scarce.

The cells of the present material are mostly solitary, rarely associated in colonies, and sometimes up to 34 μ in diameter. Its endospores are 3.5—5.0 μ in diameter. Their other characteristics are, however, entirely similar to those of the typical form.

DERMOCARPA FUCICOLA Saund. in Coll., Hold., et Setch., Phyc. Bor.-Amer. No. 801. 1901.

San Juan Island: False Bay, epiphytic on *Fucus evanescens* and *Odonthalia floccosa* in the upper littoral belt, common, but not abundant.

Brown Island: epiphytic on *Constantinea subulifera* and *Amphiroa tuberculosa* in the upper littoral belt, scarce.

DERMOCARPA VIOLACEA Croun, Ann. Sci. Nat. Bot. 9: 70, pl. 3, figs. 2 a—d. 1878.

Canoe Island: Dredged from a depth of 5 to 10 fathoms, on empytied shells, fairly common.

The cells of the local plants are usually densely aggregated into a widely expanded stratum, ovate in lateral view, subglobose or becoming angular in end view, 10—17 μ in diameter, and 16—20 μ long. The cell wall is colorless and about 1.5 μ in thickness. The cell contents are finely granular and rose red in color. The endospores are 2—3.5 μ in diameter and formed by simultaneously division of the whole protoplast of endosporangia.

As described above, the cells of the local plants are not more than 17 μ in diameter. This is the only difference between the local form and the typical one. As far as the writer can judge, other characteristics of the local form are typical.

DERMOCARPA PROTEA Setch. et Gardn., Univ. Calif. Publ. Bot. 6: 456, pl. 38, figs. 4, 5, 1918.

San Juan Island: South of False Bay, growing on on other algae in the littoral belt, scarce.

CHAMAESIPHONACEAE

CHAMAESIPHON A. Br. et Grun., 1865

CHAMAESIPHON PYLAIELLAE, sp. nov. (Fig. 1, *i*)

C. cellulis cylindricis, apicem versus leviter sed evidenter attenuatis, ad basim 3—4 μ latis, ad apicem 2.5—3.5 μ latis, 5—12 μ longis; vaginis tenuibus; exsoporis globosis vel depresso-globosis, 2.5—3.0 μ latis, 2—3.0 μ longis; contentu pallide violaceo et minute granuloso.

San Juan Island: Jekyll Lagoon, epiphytic on *Rhizoclonium lubricum,* rare.

The type specimens of this species (*Jao*: *1235B*) are epiphytic on *Pylaiella washingtonensis* Jao which were collected on the concrete wall of the outer entrance of the Lake Washington Canal, Seattle. The specimens collected in the Jekyll Lagoon are quite scattered and considered by the writer as the co-types.

In this genus, only a single doubtful species, *C. marinus* Wille, is marine in habit. As considered by Geitler (Cyan., in Rabenhorst's Krypt.-Fl. 14: 413. 1932), it is probably a species of bacteria. Judging from Wille's drawings and description of this species (in Wille and Rosenvinge, Alger Novaia-Zemlia, Dijmphna-Togtets Zool. Bot. Udbytte, Kopenhagen 1885: 4, pl, 13, figs. 1 a, b. 1885), its cells are wholly globose in form and only 0.5 μ in diameter. These characteristics show that Geitler's consideration is possibly correct. Apart from this doubtful marine species, all the others are freshwater in habit and have the cells never attenuated from the base towards the apex as found in the present new alga.

HORMOGONALES

OSCILLATORIACEAE

SPIRULINA Turp., 1827

1. Turns of the spiral not close together .... *S. major*
1. Turns of the spiral close together .... *S. subsalsa* f. *oceanica*

SPIRULINA MAJOR Kuetz., Phyc. gen. 183. 1843.

San Juan Island: Mosquito Pass, Westcott Creak, Jekyll Lagoon, and Argyle Lagoon, scattered among other algae, scarce.

MaConnell Islands in a salt pool, scarce.

Shaw Island: Neck Point, in salt marshes, fairly scarce.

SPIRULINA SUBSALSA Oerst. f. OCEANICA (Crouan) Gom., Monogr. Oscill. 274. 1893.

Associated with the preceding species, but also found on damp ground, old piles, and rotten logs along the high tide level or a little above.

OSCILLATORIA Vauch., 1803

1. Trichomes constricted at the cross walls 2
1. Trichomes not constricted at the cross walls 6
2. Trichomes 23—30 μ in diameter, apex not tapering; cells 3 to 6 times broader than length *O. Bonnemaisonii*
2. Trichomes not more than 13 μ in diameter, apex tapering; cells 2 to 3 times broader than length or nearly quadrate 3
3. Trichomes 3—5 μ in diameter; cells nearly quadrate .... *O. laetevirens*
3. Trichomes 6—13 μ in diameter; cells distinctly shorter than broad 4
4. Trichomes slightly constricted at the cross walls; apical cell not capitate and without a thickened outer wall .... *O. chalybea*
4. Trichomes distinctly constricted at the cross walls, apical cell slightly capitate and with a thickened outer wall 5
5. Plants epiphytic; cross walls not granulate .... *O. Corallinae*
5. Plants not epiphytic; cross walls granulate .... *O. nigro-viridis*
6. Trichomes 2.5—3.5 μ in diameter; cells 2 to 3 times longer than broad .... *O. amphibia*
6. Trichomes 4—20 μ in diameter; cells nearly quadrate or distinctly shorter than broad 7

7. Trichomes 13—20 μ in diameter, apex straight and not tapering; cells 3 to 6 times broader than length .... *O. limosa*
7. Trichomes 4.0—6.5 μ in diameter, apex curved and gradually tapering; cells 2 to 3 times broader than length 8
8. Trichomes here and there interrupted by inflated, refringent cells; cells 2 to 3 times broader than length .... *O. brevis*
8. Trichomes without inflated, refringent cells; cells nearly quadrate .... *O. subuliformis*

OSCILLATORIA LIMOSA Ag., Disp. Alg. Suec. 35. 1812.

San Juan Island: Westcott Creak and False Bay, scattered among other algae in the upper littoral belt, fairly scarce.

The specimens collected from the above stations are dissimilar in dimensions. Those from Westcott Creak have the cells 15—20 μ in diameter and 2.0—3.5 μ long; those from False Bay 13—15 μ in diameter 3.0—4.5 μ long. Other characteristics are, however, entirely identical with those of the typical form.

OSCILLATORIA BONNEMAISONII Crouan, 1858; Gom., Monogr. Oscill. 235, pl. 6, figs. 17, 18. 1893.

San Juan Island: A smaller cove near Deiner Point, Westcott Creak, and Mosquito Pass, growing on damp ground along the high tide level or a little above, fairly abundant.

Shaw Island: Neck Point, on damp ground along the margin of salt marshes, common and fairly abundant.

This is a common and the largest species of this genus distributed in this region. The trichomes of the local plants vary from 23 to 30 μ in diameter. The larger and the smaller ones are absent.

OSCILLATORIA NIGRO-VIRIDIS Thwaites in Harvey, Phyc. Brit. Syn., 39, no. 375, pl. 251, A. 1846—51.

San Juan Island: Friday Harbor, scattered among *Rhizoclonium riparium* on the piles in the upper littoral belt, scarce; Jekyll Lagoon and Westcott Creak, on damp ground along the high tide level, scarce.

MaConnell Island: on damp ground or floating among other algae along the margin of a salt pool, rather scarce.

The plants of this species found among other algae in water are usually solitary or in groups of a few trichomes; those growing on damp ground always form a thin but not widely expanded stratum. The specimens collected in Jekyll Lagoon and Westcott Creak have the cells 7—13 μ in diameter and only 2.0—3.5 μ long; but their other characteristics are typical.

OSCILLATORIA CORALLINAE (Kuetz.) Gom., Journ. de Bot. 4: 356. 1890.

San Juan Island: Westcott Creak, growing on soft mud along the high tide level or on floating logs, fairly scarce.

OSCILLATORIA AMPHIBIA Ag., Flora 10: 632. 1827.

San Juan Island: Westcott Creak, on soft mud or scattered among other algae along the high tide level, fairly common.

The local plants have the trichomes 2.5—3.5 μ in diameter and the cells 5.0—8.5 μ long.

OSCILLATORIA LAETEVIRENS (Crouan) Gom., Monogr. Oscill. 226, pl. 7, fig. 11, 1893.

San Juan Island: Westcott Creak, on damp stones a little above the high tide level, fairly scarce.

OSCILLATORIA SUBULIFORMIS Kuetz., 1863; Gom., Monogr. Oscill. 246. 1893.

San Juan Island: Jekyll Lagoon and Westcott Creak, on damp ground along the high tide level, scarce.

Shaw island: Neck Point, on soft mud and rotten logs in the marshes, rather common but not abundant.

OSCILLATORIA BREVIS Kuetz., Phyc. gen. 186. 1843.

San Juan Island: Friday Harbor, on piles in the upper littoral belt, scarce.

OSCILLATORIA CHALYBEA Mert. in Jürgens, 1822; Gom., Monogr. Oscill. 252. 1893.

San Juan Island: Westcott Creak, on damp ground along the high tide level, fairly scarce.

PHORMIDIUM Kuetz., 1843

1. Trichomes spiral .... *P. spirale*
1. Trichomes not spiral 2
2. Trichomes moniliform, not tapering at the apex .... *P. nostochoides*
2. Trichomes not moniliform, tapering at the apex 3
3. Trichomes 1—2 µ in diameter, slightly constricted at the cross walls; apical cell without a calyptra .... *P. tenue*
3. Trichomes 5—6 µ in diameter, not constricted at the cross walls; apical cell with a calyptra *P. uncinatum*

PHORMIDIUM SPIRALE, sp. nov. (Fig. 1, *c*)

P. libere natante; filamentis sparsis solitariis aut in stratum amorphum, mucosum, pallide aerugineum intricatis, in spiram laxam subirregularem contortis aut raro partim subrectis, spiris 5—19 µ latis, anfractibus inter se 4—35 µ distantibus; vaginis in mucum amorphum diffluentibus; trichomatibus ad genicula non constrictis, apice nec attenuatis nec capitatis, 1.0—1.5 µ latis; articulis plerumque quadratis vel diametro trichomatis paululo longioribus, 1.0—1.5 µ longis; contentu homogeneo, pallide aeruginoso; dissepimentis non granulatis; cellula apicali obtusa; calyptra nulla.

MaConnell Island: Floating in a salt pool, abundant. *Jao: 1245* (TYPE).

In general appearance, this species seems to be closely related to *P. antarcticum* W. et G. S. West, but differs from the latter chiefly in having larger dimensions and cells mostly quadrate or rarely a little longer than broad.

PHORMIDIUM NOSTOCHOIDES, sp. nov. (Fig. 1, *g*)

P. strato expanso, amorpho, gelatinoso, pallide aerugineo aut dilute brunneo, crassitudine usque ad 3 mm.; filamentis valde et irregulariter flexuosis, densissime intricatis; vaginis initio tenuibus, arctis, hyalinis, demum valde mucosis, crassissimis, plus minusve confluentibus, plerumque plus minusve fuscescentibus; trichomatibus ad genicula distincte constrictis, 1.0—1.7 µ latis, apice nec attenuatis nec captatis; articulis subdepresso-globosis, plerumque diametro trichomatis paululo brevioribus, 0.8—1.5 µ longis; contentu pallide aerugineo et minutissime granuloso; cellula apicali rotundata; calyptra nulla.

San Juan Island: Deiner Point, on floating logs, scarce. *Jao: 1258* (TYPE).

This species bears some resemblance to *P. foveolarum* Gom., but is distinguished from the latter by the following characteristics: 1, the plant mass is much thicker, without a definite outline, and usually becoming brownish in color; 2, the individual sheaths become mucilaginous and more or less confluent and mostly more or less brownish in color; 3, the trichomes in a plant mass are not parallel.

PHORMIDIUM TENUE (Menegh.) Gom., Monogr. Oscill. 169, pl. 4, figs. 23—25. 1893.

San Juan Island: Friday Harbor, mixed with other blue green algae on the piles along the high tide level or a little above, fairly scarce; Westcott Creak and Mosquito Pass, on rotten logs in the upper littoral belt, scarce.

PHORMIDIUM UNCINATUM (Ag.) Gom., Journ de Bot. 4: 355. 1890; Monogr. Oscill. 184, pl. 5, figs. 21, 22. 1893.

San Juan Island: Jekyll Lagoon, on damp ground wetted by salt water during the time of high tide, fairly common, but not abundant.

This is a freshwater species. According to the habitate of the local plants, it may be also considered as a marine form. The cells of the local plants are only 5—6 μ in diameter and sometimes up to 7 μ long. Their other characteristics are typical.

The distinction between this species and *P. autumnale* (Ag.) Gom. is inconspicuous. Judging from the diagnosis of these two species given by former algologists, the distinct specific characteristics of the first are the curved or briefly spiral apex of its trichomes and the rotund or depressed-conical calyptra of the apical cell. These two features shown in the writer's specimens are quite distinct.

LYNGBYA, Ag., 1824

1. Plants epiphytic; filaments attached in the middle and with both ends free; cell contents of living plants gray violet or purplish violet . . . 2
1. Plants free living; cell contents of living plants olive or blue green . . . 4
2. Trichomes not constricted at the cross walls, apex capitate . . . *L. Amphiroae*
2. Trichomes constricted at the cross walls, apex not capitate . . . 3
3. Trichomes 1.5—2.0 μ in diameter . . . *L. Nordgardhii*
3. Trichomes 5—8 μ in diameter . . . *L. gracilis*
4. Sheaths always colorless; trichomes 9—12 μ in diameter . . . *L. semiplena*
4. Sheaths becoming yellowish brown with age; trichomes 13—19 μ in diameter . . . *L. aestuarii*

LYNGBYA NORDGARDHII Wille, Nyt. Mag. Naturv. 55: 32. 1917.

Lyngbya epiphytica Wille, Nyt. Mag. Naturv. 51: 25, pl. 1, figs. 14—17. 1913.

Lyngbya Wille Setch. et Gardn. in Gardn., Univ. Calif. Publ. Bot. 6: 468. 1918.

Bell Island: Tufted on other algae in the littoral belt, scarce.

Turn Island: Tufted on other algae in the sublittoral belt, scarce.

LYNGBYA AMPHIROAE, sp. nov. (Fig. 1, *j*)

L. epiphytica; filamentis medio adfixis, utrinque erectis, caespitosis, rectis vel curvatis, plerumque plus minusve parallelis, 4—5 μ latis; vaginis tenuibus, hyalinis; trichomatibus ad genicula non constrictis, 3.4—4.2 μ latis, apice leviter attenuatis, capitatis, rectis; articulis 1.7—3.0 μ longis, plerumque diametro trichomatis ½-plo brevioribus; contentu pallide purpureo-violaceo, minute granuloso; dissepimentis non granulatis; cellula apicali calyptram late convexam praebente.

Turn Island: Epiphytic on *Amphiroa tuberculosa* f. *typica* in the sublittoral belt. *Jao: 1274* (TYPE).

This species differs from *L. lutea* (Ag.) Gom. in having filaments neither coiled nor entangled, trichomes smaller in diameter, apex of the trichomes capitate, and calyptra not rotund.

LYNGBYA GRACILIS (Menegh.) Rabenh., Fl. Eur. Alg. 2: 145. 1865; Gom., Monogr. Oscill. 144, pl. 2, fig. 20. 1893.

San Juan Island: South of False Bay, growing on *Pterosiphonia bipennata* in the littoral belt, scarce.

LYNGBYA SEMIPLENA (Ag.) J. Ag., 1842; Gom., Monogr. Oscill. 158, pl. 3, figs. 7—11 1893.

San Juan Island: Jekyll Lagoon and a small cove near Deiner Point, on rotten logs in the upper littoral belt, rather common.

Shaw Island: Neck Point, on damp soil along the margin of salt marshes, fairly scarce.

The local plants have the trichomes 9—12 μ in diameter, the apical cell of the trichomes up to 5 μ long and 6—7 μ in diameter, the dissepiments not at all granulate, and the sheaths not more than 2 μ in thickness. Their other characteristics are typical.

LYNGBYA AESTUARII (Mert.) Liebman, 1841; Gom., Monogr. Oscill. 147, pl. 3, figs. 1, 2. 1893.

San Juan Island: Mosquito Pass, Westcott Creek, Jekyll Lagoon, Argyle Lagoon, inner side of False Bay, and a small cove near Deiner Point, forming dark olive-green or dark blue-green stratum on soft mud, rotten logs, rocks, or masses of other algae, common.

Shaw Island: forming very widely expanded stratum in salt marshes near Neck Point and Indian Cove, abundant.

MaConnell Island: forming widely expanded stratum in a salt pool, fairly abundant.

Turn Island: West side of the Island, forming expanded stratum on damp ground a little above the high tide level, fairly common.

This is the largest species of this genus widely and abundantly distributed in this region. The specimens collected from different localities or even from a single station often show some variations in the nature of their plant mass, the dimensions of their filaments and cells, the color and nature of their sheaths, and the color of their cell contents. Former algologists basing upon one or more of such variations in some specimens have established a number of varieties and forms. Judging from the present specimens, this species is certainly variable in some of its specific characteristics, but these characteristics often appear even in a single specimen and show some transitional forms between the typical and the rather conspicuously modified ones. Under this condition, at least for the writer's specimens, it seems unnecessary to consider the specimens with some less stable variations as different forms of this species.

SYMPLOCA Kuetz., 1843

1. Apical cell calyptate .... *S. funicularis*
1. Apical cell not calyptate 2
2. Trichomes 3.0—3.5 μ in diameter, distinctly constricted at all cross walls .... *S. aeruginosa*
2. Trichomes 6—10 μ in diameter, slightly constricted at the cross walls near the apices. ***S. hydnoides***

SYMPLOCA HYDNOIDES Kuetz., Spec. Alg. 272. 1849.

San Juan Island. Jekyll Lagoon and Westcott Creak, on rotten woods or on damp ground above the high tide level, scarce.

SYMPLOCA FUNICULARIS Setch. et Gardn., Univ. Calif. Publ Bot. 6 469, pl. 41, fig. 29. 1918.

Symploca atlantica, in Coll, Hold, and Setch, Phyc Bor Amer Axs No 1356 (not of Gomont)

San Juan Island Masquito Pass and a small cove near Deiner Point, on damp ground above the high tide level, rather scarce.

The local plants have the trichomes 5—6 μ in diameter and the cells mostly quadrate or 5—7 μ long Other characteristics are typical

SYMPLOCA AERUGINOSA Setch et Gardn, Univ. Calif. Publ Bot 6, 469, 1918

Symploca laete viridis Setch et Gardn, Univ Calif Publ Bot 1 188 1903 (not of Gomont)

San Juan Island Westcott Creak and Jekyll Legoon, on damp ground above the high tide level, rather scarce.

MICROCOLEUS Desm., 1923

1 Trichomes 1 5—2 0 μ in diameter .... *M tenerrimus*
1 Trichomes 2 5—6 0 μ in diameter .... *M chthonoplastes*

MICROCOLEUS TENERRIMUS Gom., Monogr. Oscill. 93, pl. 14, figs. 9—11. 1893

San Juan Island. Scattered among *Rhodochorton tenue* on rocks along the high tide level near the new cable crossing of the Island, common, but not abundant

The cells of the local plants sometimes reach 8 5 μ in length.

MICROCOLEUS CHTHONOPLASTES (Mert) Thur, Ann Sci Nat. Bot 1 378. 1875.

San Juan Island. Westcott Creak, Jekyll Lagoon, and Argyle Lagoon, scattered among other algae along the high tide level, fairly common, but not abundant

Shaw Island Neck Point, scattered among other algae in salt marshes, fairly common, but not abundant.

HYDROCOLEUS Kuetz, 1842

HYDROCOLEUS MIRIFICUS, sp. nov. (Fig 1, *a*)

H. strato mucoso, late expanso, olivaceo viridi; filamentis adnatis, simplicibus vel superne pauce pseudoramis, vaginis amplis, mucosis, superficie exteriore erosis, usque ad 9 μ crassis, ad apicem saepius apertis, interdum omnino diffluentibus et agglutinatis; trichomatibus intra vaginam paucis, plerumque 4—6, subparallelis, in ramulis solitariis, ad genicula leviter sed distincte constrictis, passim cellulis moribundis deplanatis interruptis, 8—11 μ latis; apice non vel levissime attenuatis, eximie capitatis; cellulis 1.5—3.5 μ longis, plerumque diametro trichomatibus circiter 5 plo brevioribus; contentu olivaceo-viridi, granuloso; dissepimentis non granulatis; cellula apicali rotundata, calyptram hemisphaericam parvam praebente.

San Juan Island: Jekyll Lagoon, on floating logs, fairly common. *Jao 1267* (TYPE).

This species bears some resemblance to *H. lyngbyaceus* Kuetz., but differs from the latter chiefly in having each filament containing only a few trichomes which are nearly parallel to one another, constricted at the cross wall, not or slightly attenuated at the apices, apical cell with a small, hemispherical calyptra, and interrupted by the deplanate dead cells.

NOSTOCACEAE

NOSTOC Vauch., 1803

NOSTOC LINCKIA (Roth) Born. et Flah., Notes Alg. 86, pl. 18, figs. 1—12. 1880.

San Juan Island: Westcott Creak and a small cove near Deiner Point, scattered among other algae on damp ground along the high tide level, fairly common, but not abundant.

The colonies of the local plants are subglobose or subobovoid in young stages, becoming irregular with age. The plants collected in Westcott Creak have the cells 3.5—5.0 μ in diameter and the heterocysts 5—7 μ in diameter. Those in Deiner Point have the cells 2.5—4.5 μ in diameter and the heterocysts 3.5—5.0 μ in diameter.

ANABAENA Bory, 1822

1. Sheaths not present; spores often slightly constricted in the center, 18—26 μ long . *A. torulosa*
1. Sheaths present; spores not constricted in the center, 12—17 μ long .... *A. Vaucheriae*

ANABAENA TORULOSA (Carm.) Lagerh., Öfv. K. Vet.-Akad. Förhandl. 1883: 47. 1883.

San Juan Island: Westcott Creak, on damp ground, fairly common.

The measurements of the local plants are not entirely agreeable to those of the typical form. The cells, exclusive the apical cell of the trichomes, are 5—6 μ in diameter and 3.5—5.0 μ long. The heterocysts are 6—7 μ in diameter and 6.5—8.5 μ long. The spores are 7—8 μ in diameter and 18—26 μ long. Their other characteristics are typical.

ANABALNA VAUCHERIAE, sp. nov. (Fig. 1, *h*)

A. epiphytica; trichomatibus vaginatis, 3—5 μ latis, apicibus semper distincte attenuatis; vaginis hyalinis, initio tenuibus et levibus, aetate provecta plus minusve incrassatis, extus subrugosis; cellulis sphaerico-compressis vel sphaerico-truncatis, 2—5 μ longis; cellula apicali obtuse conica; heterocystis obovoideis vel cylindricis, 5—7 μ latis, 7—8 μ 'ongis; contentu cellularum aerugineo-viridi, granuloso; sporis cylindricis, apicibus rotundatis, solitariis vel seriatim consociatis, heterocystae utrinque contiguis, evolutione centrifuga, 6.5—8.5 μ latis, 12—17 μ longis, membrana laevi et hyalina.

San Juan Island: Jekyll Lagoon, epiphytic on *Vaucheria litorea* in the lower littoral belt, fairly common, *Jao: 1248* (TYPE); a small cove near Deiner Point, epiphytic on *Enteromorpha torta* in the upper littoral belt, fairly scarce.

This species should be compared with *A. inaequalis* (Kuetz.) Born. et Flah. It is distinguished from the latter by the obovoid or cylindrical heterocysts and the spores which are contiguous to the heterocysts and with a colorless wall at maturity. It also bears some resemblance to *A. oscillarioides* Bory, which is not an epiphhytic species and has rotund apical cells, longer spores, and trichomes aggregated into the colonies.

MICROCHAETACEAE

MICROCHAETE Thur., 1875

1. Filaments 5—7 μ in diameter; trichomes 4—6 μ in diameter; heterocysts 1 or 2 .... *M. vitiensis*
1. Filaments 10—12 μ in diameter; trichomes 8—10 μ in diameter; heterocysts single. *M. Cladophorae*

MICROCHAETE VITIENSIS Ask. in Born. et Flah., Mem. Cos. Sci. Cherbourg 25: 214. 1885.

Forma filamentis 5—7 μ latis; vaginis tenuibus; trichomatibus ad genicula non constrictis, 4—6 μ latis, basi non inflatis; cellulis 2—4 μ longis, plerumque diametro trichomatis paululo brevioribus; contentu obscure violaceo, minute granuloso; heterocystis basalibus, depresso-globosis vel subobovoideis, singulis vel binis, 5—7 μ latis, 3.5—7.0 μ longis; sporis ignotis.

San Juan Island: Jekyll Lagoon, growing on other algae in the upper littoral belt, rather scarce.

Up to date, this species is incompletely described by former algologists, although it has been recorded from several different localities. The color of its cell contents and whether its trichomes are constricted at the cross walls or not are unknown. If it has the trichomes constricted at the cross walls and the cell contents not purple or violet in color, the present form should be considered as a new variety of this species or even a new species.

The present form should also be compared with *M. grisea* Thur. which has hemispherical basal heterocysts, filaments with distinctly bulbous base, and living cell contents not violet in color.

MICROCHAETE CLADOPHORAE, sp. nov. (Fig. 1, *d*)

M. epiphytica; filamentis laxe aggregatis, 10—12 μ latis; vaginis hyalinis, tenuibus; trichomatibus ad genicula non constrictis, 8—10 μ latis, apice non attenuatis, plerumque capitatis, basi non inflatis; articulis conspicuis, 3.5—5.0 μ longis, plerumque diametro trichomatis 2-plo brevioribus; contentu violaceo, minute granuloso; heterocystis basalibus, singulis, hemisphaericis, 8—10 μ latis, 6—7 μ longis; cellula apicali plerumque subdepresso-globosis, plerumque ad 10—11 μ latis et 6—7 longis; sporis ignotis.

San Juan Island: Deiner Point, epiphytic on *Cladophora* in the upper littoral belt, rather scarce.

This species bears some resemblance to *M. aeruginea* Batters, an incompletely described species. It differs from the latter in having wider trichomes and violet cell contents.

RIVULARIACEAE

CALOTHRIX Ag., 1824

1. Heterocysts basal 2
1. Heterocysts basal and intercalary 3
2. Filaments 11—14 μ in diameter; trichomes 8—12 μ in diameter .... *C. scopulorum*
2. Filaments 12—25 μ in diameter; trichomes 12—17 μ in diameter .... *C. confervicola*
3. Filaments unbranched .... *C. crustacea*
3. Filaments branched .... *C. prolifera*

CALOTHRIX SCOPULORUM (Weber et Mohr) Ag., 1824; Born. et Flah., Ann. Sci. Nat. Bot. VII, 3: 353. 1886

San Jaun Island: Friday Harbor, on piles near the high tide level, scarce; Deiner Point, on rotten woods in the upper littoral belt, scarce; Mosquito Pass, on floating logs, scarce.

The local plants have the filaments only 11—14 μ in diameter, the trichomes 8—12 μ in diameter at their base, and the cells 3.5—7.0 μ long. The heterocysts are mostly solitary or rarely two, hemispherical, 8.5—13 μ in diameter, and 5.0—8.5 μ long. The trichomes are constricted at the cross walls only in their basal portion.

Calothrix confervicola (Roth) Ag., 1824; Born. et Flah., Ann. Sci. Nat. Bot. VII. 3: 349. 1886.

San Juan Island: Jekyll Lagoon, on rotten logs in upper littoral belt, fairly common.

The local plants have the filaments 12—25 μ in diameter, the trichomes 12—17 μ in diameter in their basal portion, and the cells 1.7—3.5 (-6.5) μ long. The heterocysts are often more than three in series and varying in length (3.5—13.5 μ).

Calothrix crustacea Thur., Notes Alg. 1: 13, pl. 4. 1878.

San Juan Island: Jekyll Lagoon, on floating logs, common.

The filaments of the local plants are 13—25 μ in diameter. The basal portion is usually somewhat narrower than the middle. The trichomes are 12—20 μ in diameter and constantly interrupted by numerous deplanate dead cells and heterocysts. The cells are 3.5—6.5 μ long.

Calothrix prolifera Flah. in Born. et Flah., Ann. Sci. Nat. Bot. VII, 3: 361. 1886.

San Juan Island: Dock of the Oceanographic Laboratories and Friday Harbor, on piles along the high tide level or a little above, fairly common.

Shaw Island: on floating logs in salt marshes, fairly scarce.

The branching type of local plants is entirely similar to that of the typical form of this species. All branches issue from the region of intercalary heterocysts as in *Tolypothrix*. In size, the local plants are not typical. They have the filaments 10—18 μ in diameter, the trichomes 6—15 μ in diameter, and the cells 2—4 μ long.

Rivularia Ag., 1824

Rivularia atra Roth, 1806; Born. et Flah., Ann. Sci. Nat. Bot. VII, 4: 353. 1886.

San Juan Island: Scattered among *Rhodochorton tenue* on rocks along the high tide level near the new cable crossing of the Island, fairly scarce.

SCYTONEMATACEAE

Plectonema Thur., 1875

Plectonema Battersii Gom., Bull. Soc. Bot. de France 46: 36. 1899.

Brown Island: Mixed with other algae on rotten woods in the upper littoral belt, scarce.

San Juan Island: Deiner Point, on floating logs, scarce; south of False Bay, epiphytic on *Fucus evanescens* in the upper littoral belt, scarce.

The local plants have the filaments usually attached in the middle and free on both ends, the trichomes pale blue-green or sometimes pale purple, and the false branches mostly single. Otherwise, they are typical. The pale purple individuals are scattered among the pale blue-green ones and entirely similar to the pale blue-green ones in other characteristics. The modification of color appeared in the local plants is probably not of a stable variation. *Plectonema Golenkinianum* Gom, have red cell contents, but is smaller than this species.

KEY TO THE GENERA

1. Plants unicellular, colonial, or either vaguely or partly filamentous 2
1. Plants filamentous 12
2. Without a formation of endospores or exsospores 3
2. With a formation of endospores or exospores 8
3. Cell division in 1 direction; sheath wanting .... *Synechococcus* (p. 164)
3. Cell division in 2 or 3 directions; sheath present 4
4. Cell division in 2 directions 5
4. Cell division in 3 directions 6
5. Colony a flat plate; cells arranged in a rectilinear series in a single layer ... *Merismopedia* (p. 164)
5. Colony a hallow sphere; cells arranged in a single layer a short distance inward from the surface of the colonial gelatinous tegument .... *Gomphosphaeria* (p. 163)
6. Plants without a colonial gelatinous tegument; sheath of individual cells not confluent *Chroococcus* (p. 163)
6. Plants with a colonial gelatinous tegument: sheath of individual cells confluent 7
7. Colonies many-celled; sheath of individual cells completely confluent with one anothar *Microcystis* (p. 162)
7. Colonies few-celled; sheath of individual cells confluent, but distinct .... *Glococapsa* (p. 163)
8. Multiplication by both vegetable cell division and endospores 9
8. Multiplication either by endospores or by exospores only 11
9. Thallus perforating a calcareous substrate, filamentous .... *Hyella* (p. 165)
9. Thallus not perforating a calcareous substrate, not filamentous 10
10. Cells usually arranged in vertical rows .... *Pleurocapsa* (p. 164)
10. Cells arranged in a stratum one cell in thickness .... *Xenococcus* (p. 164)
11. Cells not united in colonies; multiplication by exospores .... *Chamaesiphon* (p. 166)
11. Cells united in colonies; multiplication by endospores .... *Dermocarpa* (p. 165)
12. Heterocysts absent 13
12. Heterocysts present 21
13. Sheath absent, or exceptionally very evanescent 14
13. Sheath present 15
14. Trichomes regularly spiral .... *Spirulina* (p. 167)
14. Trichomes straight, curved, or irregularly and loosely spiral .... *Oscillatoria* (p. 167)
15. Trichomes single within the sheath 16
15. Trichomes two or more within a common sheath 20
16. Trichomes simple 17
16. Trichomes pseudo-branched 19
17. Sheaths diffluent uniting filaments into submembranaceous substratum .... *Phormidium* (p. 169)
17. Sheaths distinct, firm 18
18. Filaments loose and matted, not in erect tufts .... *Lyngbya* (p. 170)
18. Filaments ascending and fasciculate, forming tufted layers .... *Symploca* (p. 171)
19. Filaments free, not forming tufted layers .... *Plectonema* (p. 175)
19. Filaments densely fasciculate, forming tufted layers .... *Symploca* (p. 171)
20. Many trichomes in a common sheath .... *Microcoleus* (p. 172)
20. Few trichomes in a common sheath .... *Hydrocoleus* (p. 172)
21. Trichomes alike at both ends; heterocysts intercalary 22
21. Trichomes unlike at both ends; heterocysts basal or basal and intercalary 23
22. Trichomes much twisted into a mass of definite form .... *Nostoc* (p. 173)
22. Trichomes solitary, straight, contorted, or interwined into an amorphous mucous mass *Anabaena* (p. 173)
23. Trichomes sometimes slightly attenuated at their free end, without terminal hair. *Microchaete* (p. 173)
23. Trichomes distinctly attenuated from base to apex and with a terminal hair 24
24. Filaments solitary or in colonies of indefinite shape; sheaths firm .... *Calothrix* (p. 174)
24. Filaments united into hemispherical colonies; sheaths diffluent into an enclosing jelly. *Rivularia* (p. 175)

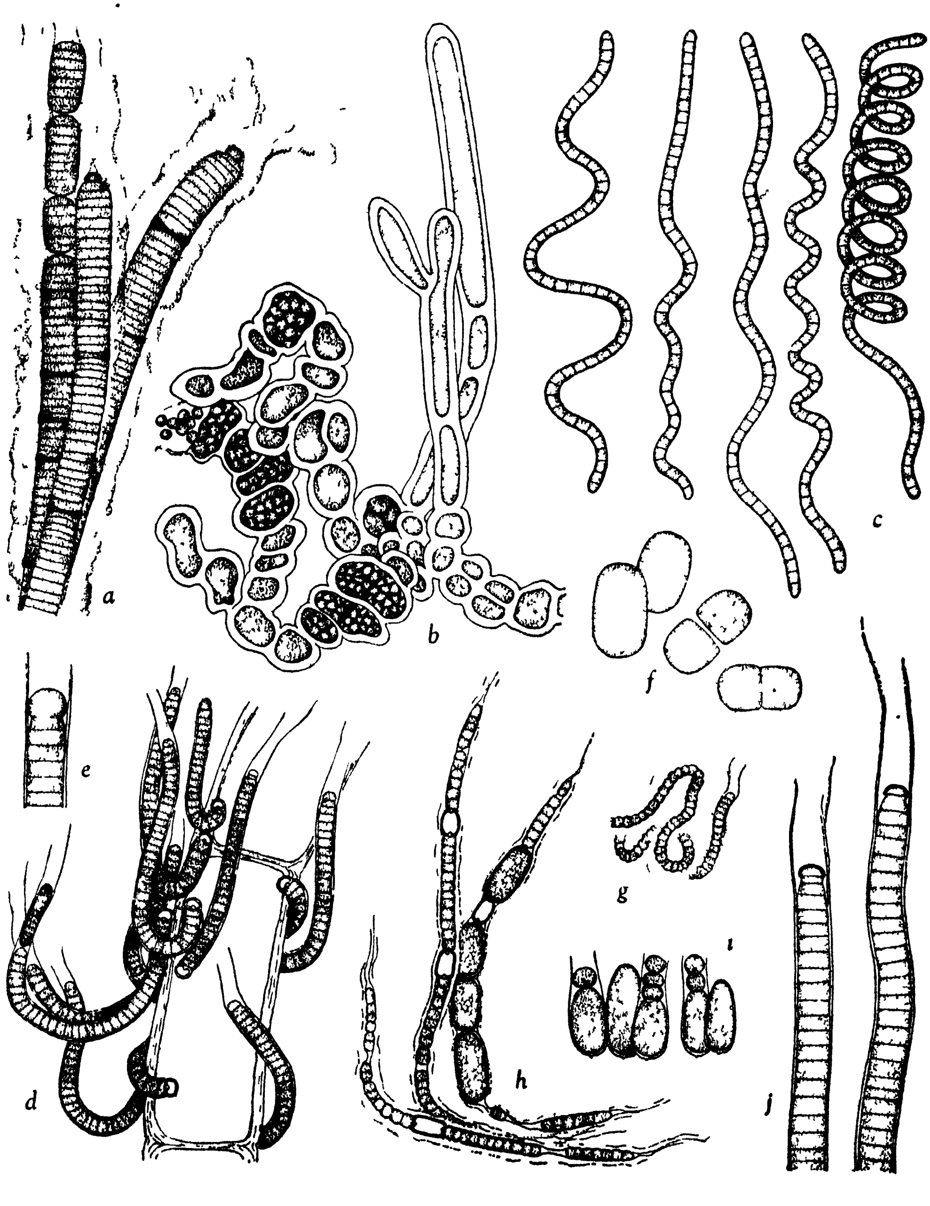

Fig. 1. *a, Hydrocoleus mirificus* Jao, sp nov ; *b. Hyella purpurea* Jao, sp nov ; *c. Phormidium spirale* Jao, sp. nov.; *d* and *e, Microchaete Cladophorae* Jao, sp. nov ; *f, Synechococcus marinus* Jao, sp nov ; *g, Phormidium nostochoides* Jao, sp. nov ; *h, Anabaena Vaucheriae* Jao, sp. nov ; *i, Chamaesiphon Pylaiellae* Jao, sp. nov.; *j, Lyngbya Amphiroae* Jao, sp. nov. Figures *a, b, h,* and *e,* × 550; figures *c, f, g, i,* and *j,* × 1100; figure *d,* × 250.

THE CRUCIFERAE OF EASTERN CHINA

TAI-YIEN CHEO

This family is characterized in general by four petals opposite each other in a cross-like figure, hence it was named *Cruciferae.* The plants of this family yield important vegetables and other products to mankind. There are numerous ornamental species for flower-gardens, but also disgustingly noxious weeds occurring everywhere in the fields. The temperate climate in this region is favorable to their growth.

In our herbarium, the preserved specimens besides the cultivated brassicas represent sixteen genera, twenty-seven species, and one variety from Eastern China. It is quite certain that more species will be found to occur in this region by more intensive future explorations. Tentative keys to genera and species are given in this preliminary report for those who are interested in this group of plants.

The writer is indebted to Dr. C. P'ei for his guidance.

FAMILY CHARACTERS—Herbs, rarely undershrubs, with often pungent watery juice; leaves cauline and radical, the latter in a rosette, cauline alternate, exstipulate, usually simple although often deeply pinnatified, frequently variable in a genus; flowers small but showy, bisexual, regular, racemed, rarely solitary on scapes or axillary; sepals 4, free, mostly soon deciduous, 2 lateral opposite the placentae often large and saccate at the base, imbricate; petals 4, seldom wanting, hypogynous, standing opposite each other in a square cross, usually clawed and with a spreading limb, imbricate; stamens typically 6 and tetradynamous (4 long and 2 short), rarely 1-2 or many, 2 outer opposite the lateral sepals, 4 inner longer, in opposite pairs; disk with usually 4 glands, opposite the sepals; pistil 1, superior, of 2 united carpels; ovary 2-celled by a placental membrane, or 1-celled, or with superimposed cellules; style short or none; stigma simple or with 2 lobes opposite the placentae; ovules 1-2 or numerous, 1- or 2-seriate on two parietal placentae, rarely solitary and erect; fruit a 2-celled, 2-valved silique (longer than broad) or silicle (as broad as long), the valves dehiscent and leaving the seeds on the persistent placentae, or indehiscent, or transversely jointed; seeds small, exalbuminous, often globular, filled with the embryo, the cotyledons in characteristic positions as accumbent[1], incumbent[2], and conduplicate[3].

About 200 genera and 1,800 species, widely distributed all over the temperate and subarctic regions; over 50 genera in China and about 16 in our region.

1. Cotyledons conduplicate; fruit elongated and beaked 2
1. Cotyledons accumbent or incumbent; fruit elongated or short, not beaked 4
2. Silique dehiscent 3
2. Silique indehiscent, terete, spongy, more or less constricted between the seeds .... *Raphanus*
3. Leaves pinnatifid or lyrate; flowers yellow; silique compressed-cylindrical, tipped with an indehiscent and usually seedless beak; valves convex, 1-3-nerved; seeds 1-seriate, globose or subcompressed, not winged .... *Brassica*
3. Leaves amplexicaul or pinnatisect; flowers violet or rose-colored; silique tetragonal, with or without a flattened 1-seeded beak; valves flat, 1-nerved; seeds 1-2-seriate, compressed, sometimes winged .... *Orychophragmus*

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1. Accumbent when radicle facing the edges of both cotyledons.
2. Incumbent when radicle turned up on the back of one cotyledon.
3. Conduplicate when cotyledons fold on either side of the radicle.

4 Fruit dehiscent, seeds solitary, several or numerous 6
4 Fruit indehiscent, seeds solitary 5
5 Flowers yellow, fruit 1-celled, samara like, flat, pendulous *Isatis*
5 Flowers white, fruit 2-celled, didymous *Coronopus*
6 Fruit a silicle 7
6 Fruit a silique 10
7 Plant glabrous or pubescent with simple hairs, silicle orbicular or obovate 8
7 Plant pubescent with stellate or branched hairs, silicle obcordate or elliptic oblong 9
8 Silicle emarginate, valves wingless or slightly winged, seeds solitary in each cell, cotyledons incumbent *Lepidium*
8 Silicle deeply emarginate, valves broadly winged, seeds 2 several in each cell, cotyledons accumbent *Thlaspi*
9 Silicle obcordate, valves convex, cotyledons incumbent, pubescence of branched hairs, radical leaves pinnatifid *Capsella*
9 Silicle elliptic oblong, valves flat, cotyledons accumbent, pubescence often stellate radical leaves simple *Draba*
10 Cotyledons incumbent 13
10 Cotyledons accumbent 11
11 Silique linear and compressed, valves nerveless, elastically dehiscent from the base, leaves entire, lobed or pinnate *Cardamine*
11 Silique terete or angled valves remaining on fruit after dehiscence 12
12 Seeds 2 seriate in each cell, leaves, at least lower ones, pinnate, plant glabrous *Roripa*
12 Seeds 1 seriate in each cell leaves lanceolate or oblong linear plant usually with appressed bipartite hairs *Cheiranthus*
13 Silique cylindric, seeds 1 seriate in each cell leaves broadly ovate, obtuse at apex and cordate at base *Eutrema*
13 Silique linear, seeds 1 or 2 seriate in each cell 14
14 Valves 1 nerved 15
14 Valves sub trinerved, plant with simple or glandular hairs *Dontostemon*
15 Leaves oblong flowers white pubescence of simple or branched hairs, rarely glabrous *Arabidopsis*
15 Leaves 2 3 pinnatifid flowers yellow pubescence of short forked hairs, often sub stellate, sometimes tomentose *Descurainia*

RAPHANUS Linnaeus

Annual or biennial herbs, glabrous or with scattered hairs, much branched, leaves mostly lyrate lobed or pinnatifid, flowers white, pink, purplish, or yellowish, slender-pedicelled, in open branched racemes, lateral sepals somewhat saccate, stamens free and unappendaged; style slender with slightly lobed stigma; fruit a long terete spongy indehiscent silique, more or less constricted between the seeds, with a long beak; seeds globose or nearly so, cotyledons conduplicate

About 8 species in Europe and E. Asia, 1 cultivated in China and sometimes escaping and growing in waste places.

RAPHANUS SATIVUS Linn., Sp. Pl. 669. 1753.

Biennial herb, root fleshy and edible, variable in size and form; leaves stalked, glabrous or roughly pilose, lower ones lyrate; flowers in branched racemes, usually white or lilac, with purple veins; fruit a terete indehiscent silique, 3-8 cm. long, spongy and containing 1-6 seeds, with extended beak.

Anhwei: Y. *Tsiang*.

Vernacular name: Lo-pu.

Distrib.: Commonly cultivated in China.

Brassica Linnaeus

Glabrous or hispid annual, biennial or perennial herbs, rootstock often woody; stems erect, branched, glabrous or with scattered simple hairs, in some of the species very glaucous; leaves large, pinnatifid or lyrate, rarely entire; flowers yellow, rarely white, in long simple racemes; sepals erect or spreading, lateral ones usually saccate at the base; petals long-clawed; stigma capitate, truncate or 2-lobed; fruit a long slender stalked or nearly sessile silique, compressed-cylindrical or 4-sided, tipped with an indehiscent and usually seedless beak; valves convex, 1-3-nerved, lateral nerves flexuose; seeds 1-seriate, globose or subcompressed, brown-black or yellowish, cotyledons conduplicate.

About 100 species, distributed in north temperate regions especially in the eastern hemisphere, many of them widely spread as weeds and others cultivated as vegetables.

The common cultivated species used as vegetables in this region are listed below. The vernacular name is given in parenthesis and followed by some distinguishing characteristics. But the detailed description of each species is omitted and many horticultural varieties are also excluded. A key modified from L. H. Bailey is given as follows:

1. Flowers large, nearly 1 to 3 cm. long, mostly creamy in color; petals long-tapering into narrow bases; sepals mostly firmly erect and not spreading, often somewhat saccate at base ... 2
1. Flowers small, about. 1 cm. long, bright yellow or sulfur-yellow; petals not prominently clawed; sepals usually separating or spreading, rarely saccate at base ... 3
2. Plant producing a terminal leaf-head; leaves large, oblong-obovate to nearly circular ... *B. oleracea* var. *capitata.*
2. Plant producing a terminal transformed flower-head; leaves long-oblong or elliptic ... *B. oleracea* var. *botrytis.*
3. Silique torose; ripe seeds prominently pitted under a hand-lens ... 4
3. Silique not torose; ripe seeds not pitted under a hand-lens ... 6
4. Root tuberous; plant glaucous; main cauline leaves petiolate ... *B. napiformis.*
4. Root not tuberous; plant green or only lightly glaucous; main cauline leaves various ... 5
5. Plant with few flowering branches ... *B. juncea.*
5. Plant with many flowering branches ... *B. juncea* var. *multiceps.*
6. Some or all the cauline leaves clasping ... 7
6. Cauline leaves not clasping, long and narrow, petioled or narrow-based ... *B. parachinensis.*
7. Root a large tuber; cauline leaves denticulate, variously clasping but not auriculate ... *B. Rapa.*
7. Root not a tuber; plants grown as potherbs or for their oily seed ... 8
8. Cauline leaves, some at least, auriculate ... 9
8. Cauline leaves not auriculate ... 10
9. Plant glaucous-green ... *B. campestris.*
9. Plant purplish ... *B. campestris* var. *purpuraria.*
10. Petiole of radical and lower cauline leaves very broad, flat and tooth-winged ... *B. pekinensis.*
10. Petiole of radical and lower cauline leaves not prominently winged ... 11
11. Cauline leaves almost orbicular or at least very broad; silique thick and short, with short stout beak ... *B. narinosa.*
11. Cauline leaves long and narrow, usually with expanded base; silique elongated and long-beaked ... *B. chinensis.*

Brassica oleracea var. capitata Linn. (Pao-tsai, head cabbage)

Producing one terminal head or giant leaf-bud; leaves large, oblong-obovate to nearly circular, with a very short broad winged petiole, and undulate margins.

BRASSICA OLERACEA var. BOTRYTIS Linn. (Hwa-ya-tsai, cauliflower)

Producing a dense terminal head of transformed decolored peduncles and pedicels and undeveloped flowers and bracts; leaves long-oblong or elliptic with a long flat mostly winged petiole and entire or minutely denticulate margins.

BRASSICA NAPIFORMIS Bailey (Fu-ching-lo-pu, turnip-rooted mustard)

Producing a short conical turnip-like white tuberous root; cauline leaves oval, with very long petioles which bear a few leaf-segments, and the upper ones narrow and clasping.

BRASSICA JUNCEA Coss. (Chieh-tsai, Indian mustard)

Radical leaves oblong or obovate, coarsely doubly serrate or dentate or notched, often variously lobed toward base or on petiole; cauline leaves not clasping; silique torose, beak mostly long and slender. It also grows wild in the fields.

BRASSICA JUNCEA var. MULTICEPS Tsen et Lee (Hsueh-li-hung, Chiu-tou-chieh)

Radical leaves numerous, oblanceolate, margins irregularly and doubly serrate, with many flowering branches.

BRASSICA PARACHINENSIS Bailey (Tai-hu-tsai, Shang-tsai, Mock pak-choi)

Distinguished from *B. chinensis* in cauline leaves, petiolate and with a narrow base.

BRASSICA RAPA Linn. (Fu-ching, Turnip)

Tuber of root globular, oblate or sometimes oblong; cauline leaves mostly denticulate, variously clasping but not auriculate.

BRASSICA CAMPESTRIS Linn. (Tsai-tai, field mustard)

Radical leaves not greatly developed or long-standing; cauline leaves usually clasping and auriculate. It also grows wild in the fields.

BRASSICA CAMPESTRIS var. PURPURARIA Bailey (Tzu-tsai-tai, purple mustard)

Stems and leaves purplish.

BRASSICA PEKINENSIS Rupr. (Pe-tsai, Hwang-ya-tsai)

Producing a compact blanched head, the inner leaves yellowish white, very tender and crisp, deficient in fiber; radical and lower cauline leaves tapering to broad flat whitened tooth-winged petiole; cauline leaves clasping. It is grown in full perfection in North China, especially in Shantung and Hopei.

BRASSICA NARINOSA Bailey (Ta-ko-tsai, Hsueh-li-ching)

Cauline leaves nearly orbicular, sessile, clasping, radical leaves in compact rosettes; silique thick and short, with stout beak.

BRASSICA CHINENSIS Linn. (Ching-tsai, Pak-choi, Chinese mustard)

Radical and lower cauline leaves without winged petiole; cauline leaves clasping, long and narrow in shape, mostly with expanded base; silique elongated and long-beaked. It also grows wild in the fields.

ORYCHOPHRAGMUS Al. Bunge

Smooth glaucous branched herbs, often woody at base; leaves amplexicaul or pinnatisect; flowers rather large, violet, purple, or rose colored; sepals erect, lateral ones saccate at base; petals clawed; fruit a silique, linear, elongate, tetragonal, with or without a flattened 1-seeded beak, valves flat, usually 1-nerved; seeds numerous, 1-2-seriate, compressed, sometimes winged, cotyledons conduplicate.

About 5 species in the Mediterranean region, Arabia, W. Asia, and 1 in China.

ORYCHOPHRAGMUS VIOLACEUS (Linn.) O. E. Schultz, Engl. Bot. Jahrb. 56, Beibl. 119: 56. 1916.

Brassica violacea Linn., Sp. Pl. 667. 1753.
Orychophragmus sonchifolius Bge., Enum. Pl. Chin. Bor. 7. 1831.
Moricandia sonchifolia Hook. f., Curtis, Bot. Mag. 102: t. 6243. 1876.
Raphanus Courtoisii Leveil., Mem. Acad. Cienc. Art Barcelona 12: 548. 1916.

Glabrous and glaucous herbs, woody at the base; radical leaves lyrate-pinnatifid, lobes variously parted; cauline simple, amplexicaul and auriculate, margin dentate; flowers mostly purple, racemed, pedicel about 1 cm. long; petals clawed, stamens 6, stigma cone-like; fruit a silique, 6-9 cm. long, tetragonal, beaked, valves with prominent mid-rib; seeds 1-seriate, ovate-oblong, flattened, brown, wingless.

Kiangsu: Tsehsia-shan, *C. N. Chen 8798,* Apr. 28, 1929; Hsuan-wu-hu, Nanking, *Chen et Teng 3921,* Apr. 4, 1931; Shanghai, *H. Migo,* May 14, 1931; Kun-shan, *H. Migo,* Oct. 14, 1933; Soochow, *C. C. Chen 934,* Apr. 1, 1933; Paohwa-shan, *Y. Y. Ho 2039,* Mar. 25, 1934; I-hsing, *Y. Y. Ho 3858,* Mar. 16, 1935; Shangfang-shan, Soochow, *H. Migo,* Apr. 5, 1935; Chulinsze, Chenkiang, *H. Migo,* Apr. 24, 1935; She-shan, Sungkiang, *Y. W. Law 779,* June 16, 1947.

Vernacular name: Chi-kao-tsai.

Distrib.: Also in Hopei, Liaoning, Szechuan and Shantung.

The young leaves are edible and flowers have ornamental value.

var. LASIOCARPUS Migo, Jour. Sh. Sci. Ins. Sect. 3, 4: 149. 1939.

Silique with dense, distinct and spreading hoary hairs, about 1 mm. long.

Kiangsu: Chulinsze, Chenkiang, *H. Migo,* Apr. 24, 1935.

ISATIS Linnaeus

Erect, tall, branching annuals or biennials, glabrous or pubescent or even tomentose; radical leaves petioled, undivided; cauline leaves sessile, usually auriculate-clasping; flowers small, yellow, in loose terminal racemes, sepals equal at the base, spreading, petals equal, entire, stamens free, without appendages, stigma sessile; fruit samara-like, 1-celled, indehiscent, flat, pendulous, margin membranaceous, foliaceous or thickened; seeds solitary, pendulous, oblong, cotyledons incumbent.

About 50 species, natives of the Mediterranean regions; 1 introduced in the Eastern China under cultivation.

ISATIS TINCTORIS Linn., Sp. Pl. 670. 1753.

Biennials, 40-80 cm. high, glabrous or slightly hairy; cauline leaves lanceolate, entire, with auricles sagittate; flowers small, yellow, racemed in a many branched panicles, pedicels slender, recurved after flowering; fruit samara-like, dark purple, 1.2 cm. long and 0.6 cm. broad, rounded at apex and tapering to base, 1-ribbed, with single seed.

Kiangsu: Nanking, *T. Shen*, Apr. 30 et June 5, 1936.

Vernacular name: Dai-tsing.

Cultivated for blue dyes.

CORONOPUS Gaertner

Annual or biennial herb, stems numerous and branched, often humifuse or procumbent, glabrous or subvillose; leaves mostly pinnatilobed or pinnaticleft, lobes entire or incised; flowers small, white, in short axillary or terminal racemes; calyx equal, open; petals entire, 4 or sometimes wanting; stamens 2 or 4, stigma sessile; fruit in pairs, emarginate, subcompressed, reticulate, marginless, 2-celled, indehiscent; seeds solitary, pendulous, subglobose-triquetrous, cotyledons linear, incumbent.

About 15 species of world-wide distribution; 2 in China and 1 in this region.

CORONOPUS DIDYMUS(L.) J. E. Smith, Fl. Brit. 3: 691. 1800.

Lepidium didymum Linn., Mant. 92. 1767.

Senebiera pinnatifida DC., Mem. Soc. Hist. Nat. Par. Ann. 7 : 144. t. 9. 1799.

Senebiera didyma Pers., Syn. 2: 185. 1806.

Senebiera incisa Willd., Enum. Hort. Berol. 2: 668. 1809.

Herb, with branched and procumbent stems; leaves pinnatifid, lobes from both sides 5-7, ovate-oblong, entire, dentate or incised; flowers small, white, in axillary or terminal racemes; petals 4, oblong, sometimes none; stamens 2 or 4, rarely 6, filaments sometimes castrate; silicle in pairs, about 2 mm. broad, emarginate, subcompressed and reticulate; seeds solitary, minute.

Anhwei: Wuhu, *H. Migo*, Apr. 15, 1941.

Fukien: Amoy, *H. Migo*, June 23, 1938.

Kiangsi: Chiukiang, *H. Migo*, Apr. 23, 1941.

Kiangsu: Nanking, *Chen et Teng 4088* Apr. 1931; Shanghai, *H. Migo*, May 13 et June 10, 1931; Kiating, *H. Migo*, May 3, 1932; Paoshan *H. Migo*, May 6, 1932; Sungkiang, *H. Migo*, Apr. 26, 1933; Liuho, *H. Migo*, June 25, 1933.

This is a roadside weed, growing on waste places.

LEPIDIUM Linnaeus

Annuals, perennials or subshrubs, erect or spreading, glabrous or pubescent with simple hairs; leaves various, simple or pinnate, all with a tapering base, the upper leaves linear or lanceolate, entire, the lower and often the middle ones incised or pinnatifid; flowers small, white or greenish, usually in terminal racemes; sepals short, equal at the base; petals sometimes 2-4 or wanting; stamens 2-6 or wanting; fruit an orbicular, oblong or obovate silicle, with septum across the short diameter, emarginate at apex; valves boat-shaped, marginless or slightly margined; seeds usually solitary in each cell, pendulous, cotyledons mostly incumbent.

About 100 species, chiefly European and Asiatic; 6 recorded in China and 3 in this region.

1. Cauline leaves perfoliate, with auriculate or sagittate clasping base; stamens 6; seeds distinctly margined .... *L. perfoliatum.*
1. Cauline leaves linear or lanceolate, entire or pinnatifid; stamens 2 2
2. Petals present; seeds minutely margined .... *L. virginicum.*
2. Petals none; seeds marginless .... *L. ruderale.*

LEPIDIUM PERFOLIATUM Linn., Sp. Pl. 643. 1753.

Thlaspi heterophyllum Cav., ex DC. Syst. 2: 542. 1821.

Alyssum heterophyllum Ruiz. et Pavon, ex DC. Syst. 2: 542. 1821.

Glabrous herb; stem erect, branching at top; radical leaves pinnatisect, petiole broader at base, cauline leaves perfoliate, with auriculate or sagittate clasping base; flowers in terminal racemes, minute, white, stamens 6; fruit orbicular, 6-7 mm. broad, slightly emarginate at apex, valves obscurely margined at top; seeds small, oval or somewhat triangular, flat, reddish brown, distinctly margined.

Kiangsu: Liuho, *T. Hida,* May 3, 1932.

Distrib.: Also in Liaoning.

LEPIDIUM VIRGINICUM Linn., Sp. Pl. 645. 1753.

Thlaspi virginianum Poir., Encyc. 7: 544. 1806.

Lepidium triandrum Stok., Bot. Mat. Med. 3: 426. 1812.

Thlaspi virginicum Cav., Desc. 413. 1827.

Annual herb, glabrous, branched; lower leaves pinnatifid, petioled, upper ones narrow or linear, entire or incised; raceme terminal, pedicel filiform, about 5 mm. long, flowers minute, petals white, stamens mostly 2, rarely 3-4; fruit orbicular, flat, 2-3 mm. broad, slightly notched and obscurely margined at the top; seeds small, oval, compressed, yellowish brown and minutely margined.

Anhwei: Wuhu, *H. Migo,* Apr. 15, 1941; Anking, *H. Migo,* June 22, 1941.

Chekiang: Hangchow, *H. Migo,* May 23, 1935.

Fukien: Kushan, *H. Migo,* July 2, 1937; Amoy, *H. Migo,* June 23, 1938.

Kiangsi: Chiukiang, *H. Migo,* Sept. 7, 1940.

Kiangsu: Shanghai, *H. Migo,* June 10, 1931; Hsiao Hsien, *Chang et Cheng 624,* Oct. 8, 1932; Paoshan *H. Migo,* May 29, 1933; Soochow, *H. Migo,* July 3, 1933; Sheshan, Sungkiang, *Y. W. Law 730,* June 15, 1947; Shanghai, *T. Y. Cheo 1501,* June 1, 1948.

Distrib.: Also in Hopei.

This is a common weed of roadsides and waste places.

LEPIDIUM RUDERALE Linn., Sp. Pl. 645. 1753.

Lepidium micranthum Ledeb., Fl. Ross. 1: 205. 1842.

Annual herb, erect or diffuse, glabrous or pubescent, very fetid; lower leaves bipinnatifid, the upper ones linear-lanceolate, entire or incised above the middle, all with a tapering base; flowers minute, apetalous, stamens 2; fruit oval or orbicular, flat, about 2 mm. wide, slightly notched and margined at the top; seeds small, brown, marginless.

Kiangsu: Soochow, *S. W. Kang 58,* Oct. 26, 1929.

Vernacular name: Chi-che-tsai.

Distrib.: Also in Hopei, Liaoning, Shansi and Yunnan.

It is also a common wild weed.

THLASPI Linnaeus

Annual or perennial herbs; leaves entire or toothed, the upper ones often clasping; flowers racemose, small, white or rarely pinkish; sepals small, erect, equal at the base; petals equal or nearly so; fruit a silicle, orbicular, obovate or obcordate, laterally com-

pressed, emarginate, rarely acute; valves boat-shaped, keeled or broadly winged, septum membranaceous, style short or long; seeds 2 or more in each cell, not winged, cotyledons accumbent.

About 60 species, mostly at temperate Europe, Asia and N. America; 2 recorded in China, 1 as a common field weed in this region.

THLASPI ARVENSE Linn., Sp. Pl. 646. 1753.

Annual, erect, glabrous herb; stem simple or corymbosely branched above; radical leaves petioled, cauline ones amplexicaul, oblong-lanceolate, usually acute, toothed, auricles sagittate; flowers white, racemed, pedicel a little longer than the fruit; fruit a flattened, obovate-orbicular, deeply notched silicle, with broad wing; seeds small, ovate, 5-7 in each cell, concentrically grooved.

Anhwei: *S. S. Tai,* Apr. 1926.

Chekiang: Hangchow, *Y. Tsiang 67,* May 1925.

Kiangsu: Nanking, *C. N. Chen 8754,* Apr. 12, 1929; same locality, *Chen et Teng 3947,* Apr. 4, 1931; Shanghai, *H. Migo,* June 4, 1931; Liuho, *H. Migo,* May 3, 1932; Woosung, *H. Migo,* Apr. 11, 1933; Soochow, *H. Migo,* May 1933; Purple Mt., Nanking, *Y. Y. Ho 2178,* May 2, 1934; Chulinsze, Chenkiang, *H. Migo,* Apr. 24, 1935.

Vernacular name: Er-lan-tsai.

Distrib.: Also in Shantung and Szechuan.

The young shoot and leaves are edible.

CAPSELLA Medicus

Small annual or perennial herb, branched; radical leaves entire or pinnatifid, rosulate; flowers small, racemed, sepals spreading, equal at the base, petals short, white; fruit short, obcordate, cuneate, ovate or oblong, laterally compressed; valves convex, septum very narrow, style short; seeds numerous, 2-seriate, narrowly margined, cotyledons incumbent.

About 6 species, distributed in N. and S. temperate regions; 1 running wild in our region.

CAPSELLA BURSA-PASTORIS (L.) Medic., Pfl. Gatt, 1: 85. 1792.

Thlaspi Bursa-pastoris Linn., Sp. Pl. 647. 1753.

Capsella Bursa-pastoris Moench, Meth. 271. 1794.

Bursa Bursa-pastoris Britton, Mem. Torr. Club 5: 172. 1894.

Annual or biennial herb, glabrous or with branched hairs; root long and tapering, stems branched; radical leaves rosulate, pinnatifid, upper lobes triangular, rarely entire, cauline leaves auriculate; flowers small, white; fruit a triangular or obcordate dehiscent silicle, valves smooth; seeds numerous, small, oblong.

Anhwei: Wuhu, *H. Migo,* Apr. 15, 1941; Anking, *H. Migo,* Apr. 18, 1941.

Chekiang: Yu-tsien, *Museum of West Lake,* May 2, 1931; Hangchow, *H. Migo,* May 23, 1935.

Fukien: Foochow, *H. Migo,* Apr. 13, 1937.

Kiangsi: Chiukiang, *H. Migo,* Apr. 22, 1941.

Kiangsu: Nanking, *Chen et Teng 3939,* Apr. 4, 1931; Kiangpu, *C. N. Chen 2490,* Apr. 1926; Woosung, *H. Migo,* May 6, 1932 et Apr. 11, 1933; Kiating, *H. Migo,* May

3, 1932 et Nov. 12, 1933; Soochow, *H. Migo,* May 13 et July 2, 1933; Chenkiang, *H. Migo,* Apr. 24, 1935.

Vernacular name: Chi-tsai.

Distrib.: Also in Hopei, Hupeh, Kansu, Kweichow, Liaoning, Shansi, Shantung, Sikang, and Szechuan.

This plant is apparently common in cultivated ground or cultivated in some places of this region and used as a green vegetable in winter.

DRABA Linnaeus

Low tufted annual or perennial herbs, often with stellate hairs; leaves simple, entire or dentate, mostly in basal rosettes; flowers white or yellow, rarely purple, in ebracteate racemes; sepals short, equal at the base; petals entire or emarginate, claws short, filaments simple, stigma nearly or quite entire; fruit short, not more than 3 times as long as broad, compressed or turgid, elliptic-oblong, ovoid or rarely linear; valves flat, rarely convex, septum broad and membranaceous; seeds several or numerous, 2-seriate in each cell, small, ovoid, compressed, not winged, cotyledons accumbent.

About 150 species, mostly of alpine and cold regions in the northern hemisphere; 30 in N. and S. Western China and 1 in this region.

DRABA NEMOROSA Linn., Sp. Pl. 643. 1753.

Draba nemoralis DC., Prodr. 1: 171. 1824.

Annual herb, 5-30 cm. high, with simple, forked or stellate hairs, leafy stem short, simple or branched; radical leaves rosulate, oblong-obovate, entire or slightly dentate; cauline leaves small, ovate-oblong, sessile, margin usually 3-6-denticulate on each side, flowers small, petals entire or merely emarginate, white, style none, stigma entire; silicle elliptic-oblong, 8 mm. long and 3 mm. broad, compressed, hairy, with nearly horizontal and spreading pedicels, about 2 cm. long; seeds 2-seriate, numerous, small, ovoid, flat and brown.

Chekiang: Hsi-tien-mu-shan, *H. Migo,* Apr. 22, 1936.

Kiangsu: Nanking, *Chen et Teng 4079,* Apr. 9, 1931; I-hsing, *C. Y. Luh 550,* Apr. 23, 1933; Soochow, *C. C. Chen 958,* Apr. 2, 1933; Purple Mt., Nanking, *Y. Y. Ho 3939,* Mar. 23, 1935.

Vernacular name: Din-lih.

Distrib.: Also in Hopei and Shantung.

This is a field-side weed and grows in dry places.

CARDAMINE Linnaeus

Annual or perennial, glabrous or slightly pubescent, often flaccid herbs, erect or ascending from tubers or scaly rhizomes; leaves entire, lobed or pinnate; flowers white, pale-purple or violet, very rarely yellow, mostly racemose; sepals equal, not saccate at the base; petals clawed; stamens 6, rarely 4; stigma simple or shortly 2-lobed; silique linear, compressed, tapering at both ends; valves nerveless or faintly nerved, separating elastically from base at maturity; seeds 1-seriate in each cell, flattened, marginless, cotyledons accumbent.

About 125 species, widely distributed in temperate regions of both hemispheres, mostly in swamps and along streams; 30 in China and 8 in this region.

1. Plant glabrous; leaves lyrate; silique linear, compressed, about 30 mm. long and 2 mm. broad, with persistent style up to 4 mm. long; seeds broadly winged .... *C. lyrata*
1. Plant pubescent; leaves not lyrate 2
2. Leaves pinnatisect to entire, terminal leaflet broadly ovate to sub-triangular; silique linear, 40-50 mm. long .... *C. Limprichtiana*
2. Leaves entirely pinnatisect 3
3. Leaflets large, 25-120 mm. long 4
3. Leaflets small, less than 10 mm. long 7
4. Cauline leaves stipulate, leaflets 11-15, ovate-oblong, margin 3-5 unequally lobed; silique linear, subcompressed, about 20 mm. long and 1 mm. broad .... *C. impatiens*
4. Cauline leaves exstipulate, leaflets 5-11 5
5. Lateral pairs unequal and slightly decurrent at base, strigose on both sides; flowers white 6
5. Lateral pairs unequal and decurrent at base, glabrous both sides; flowers pinkish .... *C. Urbaniana*
6. Silique about 10 mm. long and 1.5 mm. broad, with scattered hairs and persistent style up to 5 mm. long .... *C. cathayensis*
6. Silique more than 20 mm. long and less than 1 mm. broad, glabrous, with persistent style 2-3 mm. long .... *C. macrophylla*
7. Lateral segments 4-5 pairs, ovate to linear, margin entire or 1-2-lobed, dispersed pilose; peduncle flexuose .... *C. flexuosa*
7. Lateral segments 5-7 pairs, obliquely short ovate or orbicular, margin 3-crenate, dispersed pilose; peduncle nearly upright .... *C. hirsuta*

CARDAMINE LYRATA Bge., Mem. Acad. Sci. St. Petersb. Sav. Entrang. 12: 79 (Enum. Pl. Chin. Bor. 50) 1831.

Glabrous herb, 30-50 cm. high, with weak and decumbent runners; stem erect, angular, leaves lyrate, lateral segments 3-5-paired, nearly sessile, ovate to broadly ovate, repandous-dentate to undulate, the lower pairs becoming stipule-like; terminal ones large, broadly ovate and slightly undulate; leaves on runners usually entire above the middle, petioled, broadly ovate, undulate, emarginate at apex and subcordate at base; flowers in terminal racemes, petals white, at least twice as long as sepal, stamens 6, stigma capitate; silique compressed, slightly curved, about 3 cm. long and 2 mm. wide, with persistent style about 4 mm. long, fruiting pedicel filiform, glabrous, 1.5-2 cm. long; seeds 1-seriate, oblong, broadly winged.

Anhwei: Anking, *H. Migo,* Apr. 18, 1941.

Chekiang: Kinhwa, *H. Migo,* May 4, 1935; Lingyin, Hangchow, *H. Migo,* May 23, 1935.

Kiangsi: Chiukiang, *H. Migo,* Apr. 22, 1941.

Kiangsu: Tsehsia-shan, *Chen et Teng 20,* Apr. 14, 1931; Shanghai, *H. Migo,* June 10, 1931; Kwangyin-shan, Soochow, *H. Migo,* May 13, 1933; Shangfang-shan, Soochow, *H. Migo,* May 12 et June 2, 1933; Sungkiang, *H. Migo,* June 5, 1934; Nanking, *C. C. Chung 734,* June 5, 1935.

Vernacular name: Hsiao-shui-tien-chieh.

Distrib.: Also in Honan and Hopei.

CARDAMINE LIMPRICHTIANA Pax, Jahresber. Schles. Ges. Zool.-Bot. Sekt., 27. 1911.

C. Hickinii O. E. Sch. in Fedde, Repert. Sp. Nov. 17: 289. 1921.

Flabby herb, about 40 cm. high; stem more or less flexuous, branched, pilose; leaves membranous, pinnatifid to entire, lower cauline leaves petioled, 6-8 cm. long, terminal leaflet broadly ovate to subtriangular, subcordate at base, acuminate at apex, margin unequally crenate, lateral leaflets in 2-3 pairs, remote, small, ovate and shortly petioled;

middle cauline leaves similar in shape, but with 1 pair lateral segments; upper cauline ones simple; all leaves and petioles pilose; flowers in simple raceme, sepals ovate, membranous; petals white, obovate, apex slightly emarginate, shortly clawed, nerves pinkish, filament dilated; pistil linear, stigma capitate; silique linear, immature ones measuring 4-5 cm. long and 1 mm. wide; fruiting pedicel 1.5-2 cm. long, filiform, glabrous.

Chekiang: Hsi-tien-mu-shan, *H. Migo,* Apr. 23, 1936.

Distrib.: Only reported from Chekiang.

CARDAMINE IMPATIENS Linn., Sp. Pl. 655. 1753.

Erect annual herb, 16-40 cm. high; leaves pinnatisect, lateral leaflets 5-7-paired, shortly petioluled, ovate-oblong or broadly lanceolate, margin obtusely 3-5 unequally lobed and hairy, 10-20 mm. long and 5-10 mm. wide, with subappressed scattered hairs above, terminal ones about 25 mm. long and 10 mm. wide; cauline leaves stipuled with pilose margin; flowers small, white, in terminal and axillary racemes, often apetalous; silique linear, subcompressed, about 2 cm. long and 1 mm. broad; valves with whitish sparsely simple hairs, dehiscent spirally from base; fruiting pedicel cylindrical, hairy, about 5 mm. long; seeds 1-seriate, small, flat, oblong.

Chekiang: Hsi-tien-mu-shan, *Museum of West Lake,* Apr. 28, 1931; Hangchow, *H. Migo,* Apr. 17 et May 23, 1935.

Fukien: Foochow, *H. Migo,* Apr. 19, 1937.

Kiangsu: Paohua-shan, *Chen et Teng 199,* Apr. 19, 1931; I-hsing, *C. Y. Luh 505,* Apr. 19, 1933; She-shan, Sungkiang, *H. Migo,* Apr. 26, 1933; Kwangyin-shan, Soochow, *H. Migo,* May 13, 1933; Nanking, *P. T. Chen 14,* Apr. 18, 1935.

Vernacular name: Shui-tsai-hwa.

Distrib.: Also in Szechuan and Yunnan.

This species is distinctly characterized by 2-valves elastically dehiscent and somewhat coiled up from base of a silique at maturity.

CARDAMINE URBANIANA O. E. Schulz in Engler, Bot. Jahrb. 32: 396. 1903.

Dentaria dasyloba (non Turcz.) Matsuda, Bot. Mag. Tokyo 33: 132, 1919.

Erect herb; stem thick, hollow, angular, single or branched, with long brownish hairs at apex; leaves scattered on the stem, pinnately compound; terminal leaflet sessile, broadly lanceolate, long acuminate at apex, cuneate at base, unequally and coarsely serrate, entire near apex and base, margin pilose, about 10 cm. long and 2.5 cm. broad, lateral leaflets all opposite, usually 5-6 pairs, unequal and decurrent-sessile at base; flowers in racemes, sepals membranaceous, pale green, petals rose-colored, stamens 6, inner ones 4-, outer ones 3-mm. long, filaments manifestly dilated, pistil narrow cylindric, stigma capitate and subcompressed at center; flowering pedicel erect-spreading, filiform, 10 mm. long.

Chekiang: Hsi-tien-mu-shan, *H. Migo,* Apr. 23, 1936.

Distrib.: Also in Szechuan.

CARDAMINE CATHAYENSIS Migo, Jour. Shan. Sci. Ins. Sect. 3, 5 (3): 223. 1937.

Erect herb, with robust and slightly hairy stem, about 1 m. high; cauline leaves petioled, pinnatisect, leaflets usually 5, rarely 3 or 7, terminal ones broadly lanceolate, shortly petioled, apex long acuminate, base cuneate or rounded-cuneate, margin irregularly coarsely crenate-serrate, about 11 cm. long and 4 cm. broad; lateral ones sessile, unequal and slightly decurrent at base, subglabrous above, strigose beneath; flowers white, petals

larger and three times longer than sepals; stamens 6, filament flattened; stigma capitate, style short, ovary pilose; silique linear, subcompressed, about 10 mm. long and 1.5 mm. broad, with scattered hairs and persistent style about 5 mm. long; seeds 1-seriate, oblong, flat, 1.5 mm. long and 1 mm. broad, brown in color.

Chekiang: Chung-tien-chu, Hangchow, *C. C. Yu 24,* May 2, 1929; Shang-tien-chu, *H. Migo,* Apr. 17, 1935; Ling-yin, *H. Migo,* May 23, 1935.

CARDAMINE MACROPHYLLA Willd., Sp. Pl. 3: 484; DC. Prodr. 1: 152. 1824.

Dentaria dasyloba Turcz., Maxim. Prim. Fl. Amur. 45. 1859.

Dentaria macrophylla Bunge, Maxim. Prim. Fl. Amur. 45. 1859.

Erect herb, about 60 cm. high, mostly unbranched, leafless below, bearing 3-4-petioled pinnately compound leaves about or above the middle on stem, leaflets mostly 5, ovate to broadly lanceolate, margin unequally serrate, acuminate at apex, strigose on both sides, lateral pairs sessile and slightly decurrent at base, 6-10 cm. long, 2-3 cm. broad; flowers in terminal compound racemes, sepals hairy, ovate, tapering at apex, 3 mm. long and less than 1 mm. broad; petals white, membranaceous, obovate, tapering toward the base, more than twice as long as sepals and 2-3 mm. broad: stamens 6, anther basifixed, filaments flattened, 4-5 mm. long; pistil linear, about 5 mm. long, stylose, stigma capitate; fruit linear, 2-2.5 cm. long and less than 1 mm. broad, fruiting pedicels filiform, 1.3-0.8 cm. long.

Anhwei: *Y. Tsiang,* 1926.

Vernacular name: Chia-chin-tsai.

Distrib.: Also in Shansi and Manchuria.

CARDAMINE FLEXUOSA With., Bot. Arr. Brit. Pl. Ed. 3, 3: 578; Hand.-Mazz., Sym. Sin. 7: 360. 1931.

Small herb; stem branched from base, erect-spreading, 10-20 cm. long, somewhat angular, very flexuose, especially the fruiting peduncle, pubescent below and glabrous above; cauline leaves petioled, pinnatifid, lateral leaflets 4-5 pairs, small, ovate to linear, with acute apex and narrow base, margin entire or 1-2-lobed, terminal leaflets linear, often entire, rarely lobed, all margin dispersed pilose; silique linear, tapering toward both ends, with stigmatic point at tip, 10-20 mm. long, less than 1 mm. broad, valves smooth, nerveless; fruiting pedicel filiform, glabrous, about 5 mm. long; seeds 1-seriate, many, small, oblong to somewhat rectangular, smooth, brown.

Anhwei: Wuhu, *H. Migo,* Apr. 15, 1941; Anking, *H. Migo,* Apr. 18, 1941.

Chekiang: Dinghai, *C. Pei 2478,* Apr. 4, 1931; Kinhwa, *H. Migo,* May 4, 1935.

Fukien: Foochow, *H. Migo,* Apr. 10, 1937.

Kiangsu: Nanking, *C. N. Chen 8745,* Apr. 14, 1929; same locality, *Chen et Teng 3991,* Apr. 7, 1931; Minhang, Shanghai, *H. Migo,* Apr. 29, 1933; Shangfang-shan, Soochow, *H. Migo,* Apr. 17, et May 6, 1933; Nanking, *Y. Y. Ho 3970,* Apr. 10, 1935.

Distrib.: Also in Yunnan and Szechuan.

This species is easily distinguished from others by its flexuose peduncle which bears siliques erect or nearly so.

CARDAMINE HIRSUTA Linn., Sp. Pl. 655. 1753.

Pubescent herb, 15-25 cm. long, with erect, slender and branched stem; lower cauline leaves pinnatifid, lateral segments 5-7 pairs, usually smaller than the terminal

one, petioluled, obliquely short ovate or orbicular, margin 3-crenate, about 4 mm. long and 4 mm. broad; upper cauline leaves very small, subsessile, lateral segments 4-5 pairs, narrow or linear, 3-6 mm. long and 1 mm. broad, margin entire, terminal one entire or few-toothed, all leaves and petioles dispersed pilose; flowers in racemes, sepals 1.5 mm. long, oblong, apex obtuse, hairy on dorsal side, petals white, obovate-cuneate, apex obtuse and narrow toward base, at least twice as long as the sepals; stamens 4 or 6, inner ones 2-2.5 mm., outer ones 1.5-2 mm. long; pistil cylindric, about 2 mm. long, stigma sessile; immature silique with pedicel 7-10 mm. long.

Kiangsu: Kulin-sze, Nanking, *Chen et Teng 4053*, Apr. 8, 1931; Tsehsia-shan, *C. Y. Luh 317*, Mar. 31, 1933; Nanking, *C. C. Chung 608*, Mar. 30, 1935.

Vernacular name: Yien-chin-tsai.

Distrib.: Also reported from Fukien and Yunnan.

Roripa Scopoli

Mostly small glabrous branching herbs, known sometimes under the name Radicula and formerly as Nasturtium, annual, biennial or perennial; leaves, some or all, variously pinnatifid or pinnate or sometimes entire; flowers small, white or yellow, in terminal racemes, stamens sometimes less than 6; fruit short, terete or nearly so, valves convex and nerveless or rarely 1-nerved; seeds usually 2-seriate in each cell, many and small, cotyledons accumbent.

About 50 species of world distribution, mostly in wet and moist places in the temperate zone; 14 recorded in China and 4 in this region.

1. Silique terete or cylindric. 2
1. Silique globose, about 2 mm. in diam., turgid, with short persistent style . . . . . . *R. globosa*
2. Flowers yellow 3
2. Flowers white; silique solitary, in axil of a pinnatifid leaf or bract, 4-7 mm. long and 1-2 mm. broad . . . . *R. microsperma*
3. Lower leaves sublyrate pinnatifid, upper ones entire, broadly lanceolate, margin unequally dentate . . . . *R. sublyrata*
3. Lower leaves pinnatifid, upper ones entire, ovate to broadly lanceolate, margin irregularly serrate . . . . *R. montana*

Roripa globosa (Turcz.) Thellg., Mem. Soc. Nat. Cherbg., Ser. 4, 38: 276. 1911-12.

Nasturtium globosum Turcz., Fl. Baic.-Dahur. 1: 109. 1842-45.

Nasturtium cantoniense Hance in Jour. Bot. 378. 1865.

Robust herb, woody at base, 1/3-1 m. high; stem erect, canaliculate, lower hispid, upper glabrescent; leaves pinnatifid to entire, sessile, oblong, base shortly auriculate and semi-amplectant, apex acute to acuminate, 7-9 cm. long, 1.5-2 cm. broad, hispid on both sides, margin unequally and coarsely dentate; flowers in panicled racemes, many flowered, fruiting peduncle elongated; sepals ovate, truncate at base, 2 mm. long and 1 mm. broad; petals yellow, oblong, entire, shortly clawed, equalling or shorter than sepals; stamens 6, 1.5-2 mm. long, filament very slender; pistil about 1 mm. long, ovary globose, style very short, stigma sub-capitate; silique globose, 2 mm. in diam., turgid, with distinct persistent style, valves smooth, somewhat reticulate; fruiting pedicel filiform, horizontally spreading or slightly reflexed, 5-7 mm. long; seeds numerous, very small, ovoid, notched at one end and grooved lengthwise, light brown in color.

Anhwei: Hsi-hsien, *H. Migo,* June 3, 1935; Wuhu, *H. Migo,* June 19, 1941.

Kiangsi: Sin-chien-hsien, *H. Migo,* Sept. 1, 1940; Ling-chuan, *Y. Tsiang 9958,* June 23, 1932.

Kiangsu: Nanking, *C. Y. Chiao 729,* Mar. 2, 1927; *Y. L. Keng 1408,* May 6, 1928; *Luh et Teng 9622 et 9661,* May 31, 1931; Shangfang-shan, Soochow, *H. Migo,* June 2, 1933; Sungkiang, *H. Migo,* June 11, 1933.

Vernacular name: Shan-chieh-tsai.

Distrib.: Also in Hopei, Hupeh, Kirin, Kwangtung, Liaoning, Shantung, and Yunnan.

This species in easily recognized by its globose fruit with persistent style.

RORIPA MICROSPERMA (DC.) L. H. Bailey, Gent. Herb. 1: 25. 1920.

Nasturtium microsperma DC., Syst. Nat. 2: 199. 1821.

Nasturtium sikokianum Fr. et Sav., Enum. Pl. Jap. 2: 277. 1879.

Glabrous herb, erect, 14-25 cm. high; stem solitary or subspreading, subangular, branched above; radical leaves petiolate, pinnatipartite, lateral segments 4-5 pairs, margin irregularly and incised dentate; cauline leaves sessile, clasping and shortly auriculate, pinnately incised or irregularly serrate; flowers minute, in axil of a bract or a pinnately serrate leaf, sessile, solitary; sepals membranaceous, ovate, truncate at base, 2 mm. long, 1 mm. broad; petals white, spreading, oblong, clawed, little longer than sepals; stamens 6, 1.75-2 mm. long; pistil cylindric, about 2 mm. long, stigma sessile; silique rectus, terete, with subcapitate stigma at tip and very short pedicel at base, 4-7 mm. long, 1-2 mm. broad, valves convex, smooth, nerveless; seeds 2-seriate, very minute, ovoid, notched at one end, seed coat more or less reticulate, reddish brown.

Anhwei: Wuhu, *H. Migo,* Apr. 15, 1941.

Fukien: Foochow, *H. Migo,* Mar. 13, 1937; same locality, *H. Migo,* Mar. 28, 1937.

Kiangsi: Nanchang, *H. Migo,* Aug. 28, 1940.

Kiangsu: Nanking, *Chen et Teng 4085,* Apr. 10, 1931; same locality, *Y. Y. Ho 54,* without date; Liuho, *H. Migo,* May 3, 1932; I-hsing, *C. Y. Luh, 475,* Apr. 18, 1933; Kwanyin-shan, Soochow, *H. Migo,* June 3, 1933; Shangfang-shan, Soochow, *H. Migo,* May 12, 1933; Minhang, Shanghai, *H. Migo,* Apr. 29, 1933; She-shan, Sungkiang, *H. Migo,* Apr. 26 et 23, 1933; Paoshan, *H. Migo,* Apr. 11, 1933; Chulinsze, Chenkiang, *H. Migo,* Apr. 24, 1935.

Distrib.: It is widespread in Hunan, Hupeh, Kwangtung, Shensi, Shantung, Szechuan and Taiwan.

This is a field weed, the young shoot of which is used as a potherb by local farmers.

RORIPA SUBLYRATA (Miq.) Cheo, n. tr.

Cardamine sublyrata Miq., Prol. Fl. Hap. 5; Fr. et Sav Enum. Pl. Jap. 1: 36. 1875.

Glabrous herb, about 1/4 m. high; stem erect, more or less canaliculate, solitary or branched; radical leaves long petiolate, sublyrate pinnatifid, lateral segments subopposite, 5-6 each side, ovate-oblong, margin unequally dentate to undulate, terminal one little larger and broadly ovate; cauline leaves simple, broadly lanceolate, acute to acuminate at apex, narrow and somewhat clasping at base, 4-6 cm. long, 0.7-1.1 cm. broad, margin unequally dentate, nearly entire toward both ends; flowers in terminal raceme, numerous, sepals erect, subequal, oblong, entire, truncate at base, about 3 mm. long and 1 mm. broad; petals yellow, spreading, little longer than sepals, oblong, entire, narrow toward

base; stamens 6, inner ones 3-, outer ones 2.5-mm. long, filament broader near base; pistil cylindric, about 3.5 mm. long, stigma capitate, sessile; immature silique cylindric, with erect-spreading pedicel.

Fukien: Foochow, *H. Migo,* Mar. 13, 1937.

Distrib.: It is also reported from Chekiang and Kiangsu.

RORIPA MONTANA (Wall.) Small, Fl. S. E. U. S., Ed. 2, 1336. 1913.

Nasturtium montanum Wall, Cat. n. 4778; Hook. f. et T. And., Fl. Brit. Ind. 1: 134. 1875,

Glabrous herb, 20-50 cm. high; stem erect or ascending, striated, branching from near the base; lower leaves petiolate, pinnatifid, terminal segment broadly ovate, lateral ones unequal sided, 1-2, margin entire or somewhat undulate; upper leaves entire, sometimes with one lobe near base, ovate to broadly lanceolate, acuminate at apex, narrow toward base and more or less clasping, margin dentate to irregularly serrate; flowers in racemes, small, yellow, silique cylindric, erect-ascending or slightly curved, 10-25 mm. long and 1-1.5 mm. broad, with subcapitate stigma at tip, pedical filiform, 4-5 mm. long; seeds 2-seriate, numerous, small, ovoid, brown in color.

Anhwei: Hsi-hsien, *H. Migo,* June 3, 1935.

Kiangsu: Minhang, Shanghai, *H. Migo,* July 9 et Nov. 17, 1933; Liuho, *H. Migo,* June 25, 1933; Sungkiang, *H. Migo,* Oct. 17, 1933; Kunshan, *H. Migo,* June 10, 1934; She-shan, Sungkiang, *Y. W. Law 812,* June 17, 1947.

Vernacular name: Ye-ko-tsai.

Distrib.: Also in Hunan, Kweichow, Kwangtung, Szechuan and Yunnan.

The young shoot and leaves of this plant can be used as vegetables.

CHLIRANTHUS Linnaeus

Hoary herbs, sometimes sub-shrubby, usually with forked or appressed bipartite hairs; leaves lanceolate or oblong-linear, entire or slightly toothed; flowers large, about 2 cm. or more in expansion, mostly yellow or brown, rarely purple, in terminal racemes or spikes; sepals erect, lateral saccate at base; petals long clawed, stigmas mostly with a short spreading lobes; silique 4-sided or -angled, subcompressed, dehiscent, valves remaining on the fruit, 1-nerved, septum membranaceous; seeds 1-seriate in each cell, flattened, not winged, cotyledons accumbent.

About 20 species from the Madeira and Canary Isls., eastward to the Himalayas; 5 in western China and 1 in this region.

CHEIRANTHUS AURANTIACUS Bge., Mem. Acad. Sci. St. Petersb, Sav. Etrang. 2: 79 (Enum. Pl. Chin. Bor. 5) 1931.

Perennial herb, about 1/3 m. high; leaves oblong-linear, narrow toward base, acute at apex, with appressed bipartite hairs on both sides; flowers numerous, large, in terminal racemes; lateral sepals saccate at base, obovate, membranous; petals yellow to orange-yellow, long-clawed, spreading limbs obovate or nearly orbicular, filaments dilated; pistil 4-sided, about 1 cm. long, hairy, stigma shortly 2-lobed; silique, 4 sided, with appressed hairs.

Kiangsu: Nanking *C. Y. Luh 564,* May 4, 1933.

Vernacular name: Kwei-chu-shien.

Distrib.: Also in Hopei and Shansi.

This is commonly cultivated in flower-gardens.

EUTREMA R. Brown

Perennial herb, glabrous or slightly hairy; radical leaves long-petiolate, sheath-like expanded at base, ovate or broadly ovate, crenate, obtuse, and cordate at base, cauline ones sessile or petiolate; flowers small, in simple or panicled racemes, with or without bracts, pedicel erect, upward or reflexed after flowering; sepals erect, ovate or oblong; petals white, rarely rose-colored, limb obovate, apex rounded, base narrow and short clawed; stamens 6, base of filament expanded or not, anther oblong; pistil ovate, elliptic or in flask-shape, sometimes stipitate, ovary 2-carpelled, parietal placentae, with 3-10 ovules, style very short or wanting, stigma capitate or 2-lobed; silique short, linear, lanceolate, cylindric or subtetragonal, 2-valved, dehiscent, septum tender and usually porous; seeds few, 1-seriate, cotyledons incumbent or subaccumbent.

About 10 or more species in Oriental Asia, arctic Siberian and Himalayan; 4 recorded in China and 1 in this region.

EUTREMA REFLEXA Cheo, Bot. Bull. Acad. Sinica 2: 23. 1948.

E. yunnanense Migo, (non Franch.), Journ. Shan. Sci. Ins. Sect. 3, 5 (4): 147. 1939.

Chekiang: Hsi-tien-mu-shan, *H. Migo,* Apr. 23, 1936.

This species is characterized by simple and ebracteate raceme with reflected fruiting pedicels, while *E. yunnanense* Franch. by panicled racemes and bracteate lower flowers.

DONTOSTEMON Andrzeiowskiae

Biennial or perennial herb, erect, branched, with simple or glandular hairs; leaves narrow, linear-oblong, entire, dentate or pectinate; flowers white or slightly purple, in terminal and lateral racemes, ebracteate; sepals erect, ovate, equal at base; petals equal, caducous, clawed, limbs entire or retuse, obovate-oblong; stamens 6, tetradynamous, short filament free and filiform, longer filament dilated and usually connate below the anthers, anthers oblong, base sagittate; pistil linear, style short, cylindrical, stigma subcapitate or subbilobed; silique elongate, linear, longitudinal dehiscent, 2-valved; valves lightly convex, herbaceous, erect, margin not thickened, subtrinerved; seeds 1-seriate in each cell, numerous, pendulous, small, elliptic-ovate, compressed, marginate or immarginate, cotyledons incumbent.

About 15 species, mostly Siberian; 8 in N. China and 1 in this region.

DONTOSTEMON DENTATUS Ledeb., Fl. Ross. 1: 175. 1842.

Andreoskea dentata Bunge, Enum. Pl. Chin. Bor. 6. 1831.

Herb, about 30 cm. high, with scattered simple hairs; leaves oblong-linear, dentate; flowers pinkish, in terminal and lateral racemes, sepals erect, elliptic and entire, petals clawed, obovate, longer filaments membranaceous and each 2 united into 2 pairs, free near the anthers, stigma capitate; silique linear, about 20 mm. long and 1 mm. broad, dark red; seeds small, compressed, ovate, truncate at one end and slightly marginate at the other.

Kiangsu: Haichow, *Chang et Chen 777,* Oct. 17, 1932.

Distrib.: Also in Hopei, Liaoning and Shansi.

ARABIDOPSIS Heynhold

Annual, biennial or perennial herb, erect, tender, pubescent with simple or branched hairs, rarely glabrous; leaves oblong, radical ones petiolate, cauline ones sessile or sagittate-

amplexicaul, entire, dentate or lyrate-pinnatifid; raceme sometimes bracteate, flowers usually small, white, rarely purple or yellow; sepals erect-spreading, subequal, oblong; petals obovate-cuneate or spatulate, apex rounded or truncate; stamens 6, rarely 5 or 4, suberect, filament thin; pistil narrowly cylindric, sessile or shortly stipitate, style short, stigma depressed capitate, rarely sub-bilobed; silique linear, valves slightly convex, 1-nerved; seeds 1-, rarely 2-seriate in each cell, small, ovoid, brown, cotyledons incumbent.

10 or more species in Europe, Asia and Africa; 2 in China and 1 in this region.

Arabidopsis Thaliana (L.) Heynh., O. E. Ech. in Engler, Pflanz. 4 (105): 271. 1924.

Arabis Thaliana Linn., Sp. Pl. 2: 665. 1753.

Sisymbrium Thalianum (L.) J. Gay et Monn., Annal Sc Nat. Bot. 1, Ser. 7· 399. 1826.

Stenophragma Thalianum (L.) Cel., Kvet. Ok. Prazs. 75 1870.

Erect herb, 7-40 cm. high; stem single or branched, purplish, densely pilose at base, glabrescent near apex; radical leaves in rosettes, obovate or spatulate, apex obtuse, margin entire, with forked hairs on both sides; cauline leaves small, sessile, lanceolate-linear, acute at apex and narrow at base, margin entire; sepals oblong, 1.5-2 mm. long, petals white, spatulate, 3-4 mm. long, stamens 6, filament thin, pistil cylindrical, style short, stigma capitate; silique linear, 10-14 mm. long, less than 1 mm. wide, valves straw- or violet-colored, 1-nerved, fruiting pedicel slender, filiform, 4-6 mm. long; seeds 1-seriate, very small, ovoid, lightly brown.

Anhwei: Wuhu, *H. Migo,* Apr. 15, 1941; Anking, *H. Migo,* Apr. 18, 1941.

Kiangsu: Nanking, *Chen et Teng 4078,* Apr. 9, 1931; She-shan, Sungkiang, *H. Migo,* Apr. 26, 1933; Shangfang-shan, Soochow, *H. Migo,* Apr. 5, 1935.

Distrib.: It is also reported from Hunan, Hupeh, Szechuan and Yunnan.

Descurainia Webb et Berthelot

Annual or perennial herb, some shrubby, canescent or pubescent with short forked hairs, often sub-stellate, sometimes tomentose, with slender branching stems; leaves 2-3-pinnatifid or elegantly dissected, lower ones petiolate, upper ones sub-sessile; flowers small, numerous, in terminal ebracteate racemes, the racemes much elongating in fruit, sepals erect, early deciduous, petals ovate, usually yellow, stamens 6, erect, pistil cylindric, style very short, stigma depressed capitate; silique linear or linear-oblong, slender pedicelled, valves 1-nerved, dehiscent; seeds 1- or 2-seriate in each cell, very small, oblong or ellipsoid, wingless, 0.5-1.2 mm. long, cotyledons incumbent.

About 40 species, mostly in North America, some in Asia and Europe; 1 in E. China.

Descurainia Sophia (L.) Webb ex Engl. et Prtl., Nat. Pflf. 3 (2): 192. 1890.

Sisymbrium Sophia Linn, Sp. Pl 659. 1753.

Sophia Sophia Britton, Britt et Brown, Ill Fl. 2: 170. 1913.

Herb, 1/3—2/3 m. high, covered with short forked hairs; stems canescent and usually much branched; leaves 2-3-pinnatisect into narrowly linear or linear-oblong segments; flowers numerous, yellow, stigma depressed capitate; silique narrowly linear, 2.5-3 cm. long and about 1 mm. broad, curved upwards; fruiting pedicel filiform, ascending, 1-2 cm. long; seeds 1-seriate, numerous, small, oblong, more or less flattened.

Kiangsu: Nanking, *C. N. Chen 8770,* Apr. 8, 1929; Liuho, *H. Migo,* May 3, 1932; Paoshan, *H. Migo,* May 6, 1932; Chenkiang, *H. Migo,* Apr. 24, 1935.

Distrib.: Also in Shantung, Szechuan and Liaoning.

CYTOLOGICAL STUDIES ON SUGARCANE AND ITS RELATIVES II. F 1108 A BUD SPORT OF F 108*

H. W. LI AND C. L. LEE

F 108 was obtained from a cross P.O.J.2725 and F 46 in 1926 by the Japanese workers in Taiwan. Since its introduction, on account of its adaptibility to various types of soils, heavy production and higher sugar content, it reached its maximum cultivation occupying some 37% of all the sugarcane acreage in 1941. But recently, on account of its susceptibility to mosaic, especially at the seedling stage, its acreage has been on the decline. In 1933, a bud sport was found in the experimental plat in Taiwan (Nakamura 4). It was named F 1108. In general features, it resembled the original variety F 108 so closely, that it was almost impossible to separate them. However, F 1108 was far richer in waxy substance on the rind of the stem. Perhaps it was due to the notification of this very character that this bud sport became selected and multiplied. Since then, these two varieties have been tested out in comparative trials in the Sugar Industry Experimental Station at Tainan, Taiwan and the results of these trials are tabulated in Table I.

TABLL 1. COMPARISON OF F 1108 AND F 108

	Year	F 1108	F 108	Difference
Yield per hectare in catties (0 6 kilo)	1941	185,200	186,400	
	1942	139,000	127,200	
	1943	108.500	91,000	
	Average	144,233	134,866	+ 9,367
Sugar content in % (brix)	1941	19.93	18 36	
	1942	19.29	18.99	
	1943	20.31	19.88	
	Average	19.84	19.04	+ 0.76
Sugar purity in %	1941	93.50	91.58	
	1942	92.24	90.69	
	1943	93.86	93.71	
	Average	93.20	91.99	+ 1.21

From Table 1, it can be seen that the sport variety F 1108 outyielded its parental variety F 108 in the amount of cane produced per unit area, as well as having a relatively higher sugar content and purity, in the tests carried out from 1941-1943 inclusive. Even though statistical treatment was not applied to the results, judging from the general trend showed by F 1108, the bud sport variety is certainly the better. It differs from its parental variety not only in external appearance, but in some specific physiological aspects, which are inherent characters. A possible explanation for this difference will be offered when their cytological differences have been examined.

*This was a cooperative project between Sugar Corporation of Taiwan and the Institute of Botany, Academia Sinica. The authors are very grateful to Dr. C. S. Loh, who kindly placed the material at the authors' disposal and gave all the facilities required to make this investigation possible.

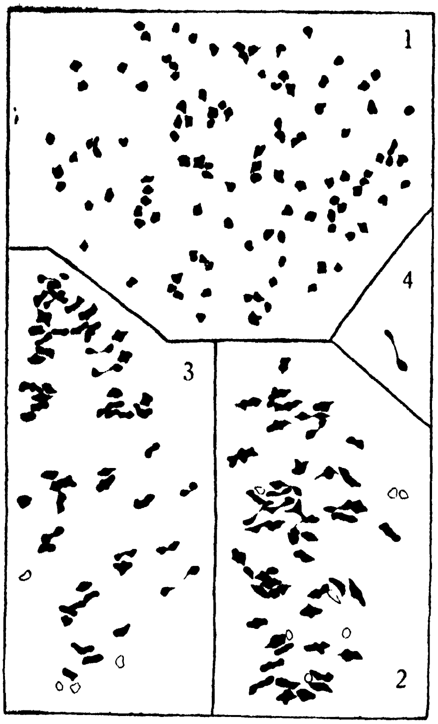

Fig. 1. F 108 Anaphase 111 chromosomes. (750x)
Fig. 2. F 108 MI 52^{II} 7^{I}=111. (750x)
Fig. 3. F 1108 MI 55^{II} 4^{I}=114. (750x)
Fig. 4. F 108 Unequal pair at MI. (750x)

CYTOLOGICAL OBSERVATIONS

Meiosis was studied by the aceto-carmine smear method, as described elsewhere (Li, et al. in the press). Moriya (3) reported the chromosome number of F 108 as found in root tip counts to be 109. At anaphase I., a very clear figure was obtained, showing 111 to be the exact number (Fig. 1). The chromosomal configurations of these two varieties at MI. are shown in Table 2. (Fig. 2-3).

F 1108 had 114 chromosomes as its somatic number, three more than its parental variety F 108. In general, the frequency of bivalents and univalents was about the same in different cells studied for these two varieties; but more bivalents seemed to have disjoined more precociously at MI in F 108, and as a result, more univalents were observed. One tetravalent was observed in F 1108 besides its bivalents and univalents, but none was seen in F 108. This was not conclusive however because only a few cells were studied in each variety.

In one instance, a bivalent with unequal pairing was observed (Fig. 4). This probably involved two unlike chromosomes belonging originally to Glagah that had homologous end.

Stages subsequent to first metaphase were more or less similar to P.O.J. 2725 and other related lines as described elsewhere (Li et al. in the press).

TABLE 2. CHROMOSOMAL CONSTITUTION OF F 108 AND F 1108 AT MI.

Variety	Frequency	IV	III	II	I	Total
F 108	1			54	3	111
	1			52	7	111
	2			51	9	111
	1			50	11	111
	1			48	15	111
	1			47	17	111
	1			45	21	111
	1			41	29	111
	Total 9					
F 1108	1			56	2	114
	2			55	4	114
	2			54	6	114
	1	1		51	8	114
	2			52	10	114
	Total 8					

DISCUSSION

It is highly probable that the additional three chromosomes originated from non-disjunction in mitosis of F 108. F 108 approximately has 100 *S. officinarum* chromosomes, and the remaining belong to *S. spontaneum*. In other words, it is not very different from P.O.J. 2725, its female parent (Li, et al. in the press). Unfortunately, the pedigree for the male parent, F 46 can not be fully traced, nor are the chromosomal number known for all of the parents used in the pedigree. Be it remembered that the chromosomes contributed originally from *S. spontaneum* (Brandes 1.) lend aid to mosaic resistance in noblecane varieties. Gradation of resistance as exhibited by different varieties of P.O.J. and others would mean that mosaic resistance is governed by a complex of genes that are located on different chromosomes of Glagah. This seems to check up very well with the fact that the less Glagah chromosomes retained in a variety after repeated backcrossing to the noble-cane, the less is the resistance for mosaic. From Table 2, it can be noticed that F 108 has an odd number of univalents, and they are assumed to belong to Glagah. In F 1108, on the other hand, an even number of univalents is invariably met with. Thus F 1108 must have an extra Glagah chromosome. Since both F 108 and F 1108 react more or less similarly, giving a low resistance to mosaic, it is assumed therefore, that genes for mosaic resistance are not cumulative in effect. Of course this does not exclude the possibility that the extra Glagah chromosome, as well as it original chromosome, contain no genes for mosaic resistance.

It remains, therefore, to account for the other two extra chromosomes. Most probably, they belong to chromosomes of noble cane. Moreover, they involve two different chromosomes instead of one homologous pair, for the odds would be against their simultaneous non-disjunction. One of the two is associated with the higher sugar content, and the waxy material on the rind of the sport line F 1108. In selection for seedlings for higher sugar content, it is a general practice to select those with more waxy material on the cane (personal communication with Dr. Loh, of Sugarcane Research Institute, Pingtung, Taiwan). Thus, it seems that these two characters are rather closely linked. At least they are on the same chromosome, if they are not governed by the same gene. Li et al. (in the press) put forward the hypothesis that sugar content is governed by a cumulative genic effect. Should this be at all true, it would mean that this extra chromosome ought further to augment the sugar content in the sport line. This explains the increase of the sugar content of 19.04% in F 108, to 19.84% in F 1108, less than 1%, from three years average.

Likewise, cumulative genic effect may be offered as an explanation for the 7% increase in yield by the sport, compared with its parental variety. One, or both, of the extra noblecane chromosomes may contribute to the same effect. It is generally known that the vegetative growth of a tetraploid is better, in general, than its original diploid. Further increase of favourable extra chromosomes would undoubtedly enhance of cumulative genic action, and thus give a better yield.

Should the hypothesis just proposed be correct accumulation of more favorable chromosomes would have a decided advantage. Sugarcane breeders can take advantage of this fact, and be alert for the appearance of bud mutations of this kind. At all events

the bud sport F 1108 has a decided advantage over its parental variety F 108 for use as one of the parents in future breeding experiments.

SUMMARY

F 108 has 111 somatic chromosomes. A sport, named F 1108, has arisen from it, characterised by having more waxy material on the rind, and has 114 chromosomes. These three extra chromosomes arose from non-disjunction in mitosis.

From three years' comparative study of these two varieties, it has been found that F 1108 outyielded its parental variety F 108 by about 7% in total yield and about 1% in sugar.

Meiosis was studied in detail. It was found that one extra chromosome belonged to *S. spontaneoum*. While the other two belonged to *S. officinarum*.

The increase in sugar content and yield was explained by the cumulative genic effect of these two extra chromosomes from *S. officinarum*.

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WOOD ANATOMY OF THREE SPECIES OF PINACEAE

TIEN-HSIANG HO

The variation in xylem elements has been demonstrated and statistically analysed by F. H. Frost, H. E. Desch, I. W. Bailey and Anna F. Faull, B. J. Rendle and S. H. Clarke, L. Chalk and M. M. Chattaway, D. A. Kribs, E. S. Barghoorm, Jr., M. W. Bannan, etc. The present paper is the result of the observations on the structural patterns of three Chinese woods, viz. *Abies Fabri* (Mast.) Craib, *Picea Neoveitchii* Mast. and *Tsuga yunnanensis* (Franch.) Mast., with special reference to their variability within small samples.

The anatomical technique used for wood preparation is a combination of those of Brown (2) and Franklin (6,7), but somewhat modified. Three samples have been selected at the same plane from one specimen for each species. Each block has a radial length of 15 mm., a vertical height of 7 mm. and a tangential thickness of 5 mm. From each of the three samples, 12-16 transverse sections, 15-20 radial

longitudinal sections and 15-20 tangential longitudinal sections have been selected. In sectioning, the slice angle was set at about 30° and the clearance angle at 5.° The tangential longitudinal sections were cut separately from the earlywood portion, the latewood portion and the portion passing through the ring boundary. Several sections of the same kind were mounted on a slide for the convenience of study. Chips for maceration were taken from the neighbourhood of each sample about match stick size. A water bath was used to treat the material as recommended by Brown (2). Franklin's method (5) in making permanent stained preparations of macerated wood fibres was adopted.

For the descriptions of the principal anatomical features used for diagnostic purposes Phillip's work (9) was generally followed. The terminology employed here is that approved by the International Association of Wood Anatomists (8). Statistical methods introduced in the present paper are those of Snedecor (13). Regarding the symbols, $\bar{x}$ is the mean, s the standard deviation, and e the standard error (13).

ABIES FABRI (MAST.) CRAIB

General. Growth rings distinct: $\bar{x}$ 4.29 s 1.44 e 0.48 mm. Latewood inconspicuous, occupying in average 23.27% of the width of the growth ring; not defined 88.89%, more or less defined 11.11%. Dimpled grain absent.

Tracheids. Pits on radial walls bordered, not alternate, not multiseriate, but uniseriate, very rarely biseriate at the tips of some wide-lumened earlywood tracheids, ovoid-circular to circular, not eroded, without callitroid thickenings, inner apertures lenticular, slightly larger than the outer, obliquely inclined, appearing in the form of an X; margins of tori not scalloped. Pits on tangential walls present in latewood and also in the first rows of earlywood tracheids, circular-ellipsoid to circular, inner apertures lenticular to linear, extending to the rim of the border, obliquely inclined, appearing in the form of an X or V. Spiral thickenings absent throughout the growth ring. Trabeculae sporadically present. Length of ordinary tracheids: of earlywood $\bar{x}$ 1988.78 s 771.45 e 77.15 u; of latewood $\bar{x}$ 2796.42 s 525.84 e 52.58 u. Latewood tracheids not prominently thick-walled: wall thickness $\bar{x}$ 7.38 s 1.69 e 0.40 u; lumen width $\bar{x}$ 5.79 s 3.58 e 0.84 u. Intercellular spaces not frequent, almost absent. Resinous tracheids in latewood 88.24%, in earlywood 11.76%; associated with ray 57.89%, not associated with ray 42.11%; solitary 35.31%, multiple 11.76%, radial series 35.29%, tangential line 11.76%, in group 5.88%. Strand tracheids very rarely present near the ring boundaries.

Parenchyma. Parenchyma absent.

Rays. Ray tracheids regularly absent. Some ordinary parenchymatous marginal cells near the ring boundaries with an obliquely upright arrangement present and appearing like the ray tracheids in form. Pits on horizontal walls having widely spaced cavity of constant width extending to the primary wall. Indentures present. End walls nodular. Horizontal walls of ray-cell thicker than those of tracheid: thickness of ray cell wall $\bar{x}$ 4.25 s 0.84 e 0.12 u; that of tracheid wall $\bar{x}$ 4.02 s 0.83 e 0.12 u. End walls of ray cells in earlywood thicker than the horizontal walls: thickness of end wall $\bar{x}$ 5.69 s 0.64 e 0.17 u; that of horizontal wall $\bar{x}$ 4.53 s 0.64 e 0.17 u; and that of adjacent tracheids $\bar{x}$ 4.34 s 0.54 e 0.14 u. Cross-field pits: taxodioid 78.91%, piceoid

12.65%, and cupressoid 8.44%; the two latter types usually absent from the ray tissue at the beginning part of earlywood. Orientation of pit apertures variable, but mostly obliquely disposed (90%). The number of pits per cross-field: $\bar{x}$ 1.50 s 0.59 e 0.01 pit. Rays 34.81 per mm.^{2}, never biseriate, rarely (1.11%) having two cells in a ray arranged in pair, rarely more than 15 cells high (up to 24 cells), $\bar{x}$ 7.73 s 3.89 e 0.09 cell, rarely (1.33%) two rays joined longitudinally together in line. Appearance of ray cells in tangential section: elongated 69.23%, approximately iso-diametric 13.46%, intermediate between the two forms 17.31%. Dark cell contents of resinous nature rarely present (7.69%). Crystals present: rhombohedron 2.33% hexagonal prism 4.65%, normal diametral prism 81.40%, abnormal diametral one 11.62%.

Resin Canals. Normal vertical and horizontal resin ducts absent. Traumatic ducts also absent.

Szechwan: O-mei: *H. L. Sun T106* (Acad. Sinica 332) 1939-40.

PICEA NEOVEITCHII MAST.

General. Growth rings distinct: $\bar{x}$ 1.84 s 0.86 e 0.23 mm. Latewood conspicuous, occupying in average 40.62% of the width of the growth ring; not defined 42.86%, more or less defined 21.43%, sharply defined 35.71%. Dimpled grain absent.

Tracheids. Pits on radial walls bordered, not alternate, not multiseriate, but predominantly uniseriate, occasionally biseriate at the tips of some wide-lumened earlywood tracheids, circular, not eroded, without callitroid thickenings, inner apertures lenticular, extending to the rim of the border, obliquely included, appearing in the form of an X; margins of tori not scalloped. Pits on tangential walls present in latewood and also in the first rows of earlywood tracheids, circular, inner apertures lenticular, included, obliquely inclined, appearing in the form of an X or V. Spiral thickenings present in earlywood, and well developed in latewood near the ring boundaries. Trabeculae occasionally present in earlywood. Length of ordinary tracheids: of earlywood $\bar{x}$ 2245.71 s 600.11 e 60.01 u; of latewood $\bar{x}$ 2780.13 s 542.36 e 54.24 u. Latewood tracheids thick-walled: wall thickness $\bar{x}$ 7.97 s 1.67 e 0.32 u; lumen width $\bar{x}$ 3.44 s 2.50 e 0.47 u. Intercellular spaces absent. Resinous tracheids in latewood rarely present. Strand tracheids present in the neighbourhood of the wood parenchyma strands surrounding normal vertical resin ducts; in latewood 46.67%, near the ring boundaries 20.00%, through the boundaries 33.33%. Mixed strands present in the same position as strand tracheids.

Parenchyma. Parenchyma absent.

Rays. Ray tracheids regularly present, inner face of the walls minute dentate. Low rays (1-4 cells high) consisting entirely of ray tracheids. In higher rays, the ray tracheids occurring in 1-4 rows along the margins, or sometimes interspersed. Pits on horizontal walls having cavity like that of *A. Fabri*. Indentures present. End walls nodular. Horizontal walls of ray-cell thicker than the walls of tracheid: thickness of ray cell wall $\bar{x}$ 5.42 s 0.57 e 0.09 u; that of ordinary tracheid wall $\bar{x}$ 5.06 s 0.70 e 0.12 u. End walls of ray cells in earlywood thicker than the horizontal walls: thickness of end wall $\bar{x}$ 6.59 s 1.07 e 0.28 u; that of horizontal wall $\bar{x}$ 5.74 s 0.75 e 0.20 u; and that of adjacent ordinary tracheids $\bar{x}$ 5.59 s 1.31 e 0.34 u. Cross-field pits

wholly piceoid, with apertures obliquely disposed. The number of pits per cross-field: $\bar{x}$ 2.55 *s* 0.98 *e* 0.03 pit. Rays 44.06 per mm.^{2}, never biseriate, very rarely (0.64%) having two cells in a ray arranged in pair, rarely more than 15 cells high (up to 29 cells), $\bar{x}$ 6.60 *s* 3.95 *e* 0.08 cell, very rarely 2 or 3 rays (less than 2%) joined longitudinally together in line. Appearance of ray cells in tangential section: elongated 70.33%, approximately iso-diametric 7.69%, intermediate between the two forms 21.98%. Dark cell contents of resinous nature present (33.00%). Crystals present: cubical 2.50%, rhombohedron 8.75%, hexagonal prism 35.00%, diametral one 53.35 %.

Resin Canals. Normal vertical resin ducts present. In earlywood 19.05%, singly and associated with ray 11.90%, in pairs and intervened by rays 7.14%. In latewood 80.95%, singly 16.67%, singly and associated with ray 28.57%, in pairs 7.14%, in pairs and intervened by rays 28.58%. Wood parenchyma strands present: in earlywood 10.53%, in latewood 89.47%; associated directly with normal ducts 52.63%, or through ray tissue 47.37%. Crystals of diametral prism appearing occasionally in the strands. Normal horizontal resin ducts present, 1.04 per mm.^{2} Epithelial cells thick-walled, the number of the cells per duct $\bar{x}$ 7.33 *s* 0.77 *e* 0.09 cell. Vertical traumatic ducts present in latewood: canal forms occurring in tangential grouping and intervened by rays; cyst-like forms occurring singly and mostly associated with ray (75.00%), elliptic 18.75%, ovate-elliptic 12.50%, ovate 18.75%, irregular-shaped 50.00%; tracheid-like cysts sporadically distributed, thin-walled, mostly associated with ray. Horizontal traumatic ducts, short-formed, occurring occasionally in latewood.

Locality (?): *Dept. For., Univ. Nanking s. n.* (Acad. Sinica 246).

TSUGA YUNNANENSIS (FRANCH.) MAST.

General. Growth rings distinct: $\bar{x}$ 2.83 *s* 1.13 *e* 0.34 mm. Latewood conspicuous, occupying in average 44.56% of the width of the growth ring; not defined 45.45%, more or less defined 27.27%, sharply defined 27.28%. Dimpled grain absent.

Tracheids. Pits on radial walls bordered, not alternate, not multiseriate, generally uniseriate throughout the length of the tracheids, only biseriate in some wide-lumened earlywood tracheids, ellipsoid to ovoid-circular, not eroded, without callitroid thickenings; minute, irregularly arranged thickening bars on the surface of the pit chamber, not the pit membrane (9, p.296), radiating from the torus present; inner apertures lenticular, slightly larger than the outer, obliquely inclined, appearing in the form of an X; margins of tori not scalloped. Pits on tangential walls present in latewood appearing like those of P. *Neoveitchii.* Spiral thickenings absent throughout the growth ring. Trabeculae present. Length of ordinary tracheids: of earlywood $\bar{x}$ 2763.42 *s* 627.78 *e* 62.78 *u;* of latewood $\bar{x}$ 3005.78 *s* 522.56 *e* 52.26 *u*. Latewood tracheids thick-walled: wall thickness $\bar{x}$ 7.60 *s* 1.40 *e* 0.29 *u;* lumen width $\bar{x}$ 4.58 *s* 3.79 *e* 0.77 *u*. Intercellular spaces infrequent Strand tracheids present in the vicinity of the ring boundaries.

Parenchyma. Parenchyma present, strand-like; sparse and scattered near the outer face of the latewood. Transverse walls nodular; the number of nodules per end wall $\bar{x}$ 4.48 *s* 1.24 *e* 0.17 nodule.

Rays. Ray tracheids regularly present, inner face of the walls smooth. Pits on horizontal walls having cavity becoming wider towards the lumen

of the cell and not extending to the primary wall. Indentures present. End walls nodular. Horizontal walls of ray-cell thicker than those of tracheid: $\bar{x}$ 5.78 *s* 0.44 *e* 0.06 *u*; that of ordinary tracheid walls $\bar{x}$ 5.44 *s* 0.32 *e* 0.04 *u*. End walls of ray cells in earlywood thicker than the horizontal walls: thickness of end wall $\bar{x}$ 5.88 *s* 0.91 *e* 0.24 *u*; that of horizontal wall $\bar{x}$ 5.48 *s* 0.65 *e* 0.17 *u*; and that of adjacent ordinary tracheids, $\bar{x}$ 4.97 *s* 0.72 *e* 0.19 *u*. Cross-field pits: taxodioid 73%, piceoid 27%; apertures obliquely disposed. The number of pits per cross-field: $\bar{x}$ 2.47 *s* 0.90 *e* 0.02 pit. Rays 25.75 per mm.^{2}, never biseriate, very rarely (less than 3%) having two cells arranged in pairs, rarely more than 15 cells high (up to 31 cells), $\bar{x}$ 7.55 *s* 4.68 *e* 0.12 cell. Appearance of ray cells in tangential section: elongated 78.09%, approximately isodiametric 1.12%, intermediate between the two forms 20.79%. Dark cell contents of resinous nature present (33.33%), drop-like, or filling the cell-lumen in latewood near the ring boundaries. Crystals absent from earlywood, usually occurring as hexagonal prism or crystal sands in latewood.

Resin Canals. Normal vertical and horizontal resin ducts absent. Vertical traumatic ducts present, all cyst-like: in latewood 75.51%, in the transition from earlywood to latewood 23.47%, in earlywood only 1.02%; associated with ray 69.74%, not with ray 30.26%; singly 67.36%, in radial groups of 2-4 cysts 32.64%; elliptic or almost elliptic 82.10%, irregularly shaped 17.90%. Traumatic horizontal ducts present only in latewood, generally elliptic, up to 147.10 x 43.71 *u*.

Szechwan: O-mei: *H. L. Sun T112* (Acad. Sinica 335) 1939-40.

DISCUSSION

The variation in cell size and variation in the proportion of different tissues have been discussed in great details by Desch (3,4). Bailey and Faull (1) state that most anatomical characters which have been supposed as conservative qualitative characters as well as quantitative characters fluctuate considerably. Rendle and Clarke (11,12) indicate the extent in which certain variable anatomical features can legitimately be used for distinguishing species.

The results of the investigations of anatomical variation in the wood of three conifers examined are interesting. The cross-field pits in earlywood show great variation in *Tsuga yunnanensis*, considerable variation in *Abies Fabri* and no variation in *Picea Neoveitchii*. Different types of pitting may occur in the same ray tissue and even within the same cross-field as in *T. yunnanensis* and *A. Fabri*. As ray running through the ring boundaries seen in radial section, ray tracheids and ray parenchyma cells appear to be interchangeable (10). In *A. Fabri*, the ray parenchyma cells of the marginal row standing by the ring boundary sometimes tend to have an obliquely upright arrangement and look like the ray tracheids in form.

From the above analysis, it shows that the xylem elements vary not only with species but also within the different growth rings of each sample. It seems that the hypothetical normal type (12) of a given species can be obtained only by careful measurement and statistical treatment. This is especially important when the material for examination is limited to a small sample.

SUMMARY

A study of the woods of *Abies Fabri, Picea Neoveitchii* and *Tsuga yunnanensis* indicates that variation both in cell size and in the proportion of different tissues is prominent. Variation in the length of ordinary tracheids both in earlywood and latewood is considerable. The type of cross-field pits, and the number of pits per cross-field are variable.

The degree of development of ray tracheids and the interchangeability between ray tracheids and ray parenchyma cells are shown in *T. yunnanensis.*

A. Fabri and *P. Neoveitchii* have end walls of ray cells thicker than the neighbouring horizontal walls which, in turn, are thicker than the adjacent ordinary tracheid walls in earlywood. *T. yunnanensis* has the thickness of end walls similar to that of the horizontal walls, and both walls being thicker than those of the earlywood tracheids.

Thanks are due to Prof. Y. Chen of the University of Nanking and Dr. W. P. Fang of the National Szechuan University who have kindly supplied wood specimens for the present study; and also to Prof. S. C. Teng and Dr. F. H. Wang for their help in preparing the manuscript.

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NOTES ON THE GENUS METASEQUOIA

S. C. TENG

Metasequoia was originally a fossil genus founded in 1941 by Miki (7) upon an old species *Sequoia disticha* Heer and referred to the family Taxodiaceae. As characterized by Miki, the genus possesses cones like those of *Sequoia,* but is distinguishable from the latter by the decussate arrangement of scales and by the delicate peduncle with scale leaves at the base. Its foliage shoots resemble those of *Taxodium* but differ from the latter in having distichous leaves with stomata parallel to the midrib on the ventral side.

In this genus, Miki also includes *Sequoia japonica* Endo which he (6) has previously considered to be synonymous with *Sequoia disticha* [*Metasequoia disticha* (Heer) Miki]. Hu (3) adds the third species by transferring *Sequoia chinensis* Endo to the present genus. *Sequoia Onukii* Endo is regarded by Miki (7) as a synonym of *Metasequoia disticha.* According to Endo (2), it is similar to *S. chinensis* [*Metasequoia chinensis* (Endo) Hu] and differs only in the number and shape of cone-scales. Both species have South Manchuria as their type locality.

The recent discovery of living specimens of *Metasequoia* in Wanhsien, Szechuan, and Lichuanhsien, Hupeh, has aroused much excitement. Many popular articles on this subject have appeared on newspapers and periodicals, especially in China. A special committee has been organized and a national park is going to be created for the preservation of this "living fossil". No other similarly interesting genera, as *Glyptostrobus, Taiwania, Pseudolarix, Amentotaxus* and others, have received so much attention in this country.

Upon the materials collected from living trees, Hu and Cheng (4) describe a new species under the name *Metasequoia glyptostroboides.* They proceed even further by erecting a new family Metasequoiaceae.

An examination of the co-type specimen kept in the herbarium of the Institute of Botany, Academia Sinica, and the original description of *Metasequoia glyptostroboides* reveals that the characters of the living plant agree closely with those of *Metasequoia disticha* as described and illustrated by Miki (7). Transverse and longitudinal sections of branchlets and microscopic examination of the epidemis peeled off from the leaves of *M. glyptostroboides* show that the leaves are distichous and the stomata are paralled to the midrib on the ventral side of the leaf, exactly as in *M. disticha.*

Thus to the list of synonyms of *Metasequoia disticha,* which already includes *Sequoia Onukii* Endo and *S. japonica* Endo, should be added *Metasequoia glyptostroboides.* The generic diagnosis of *Metasequoia* and the description of *M. disticha* may be supplemented on the basis of the living material. Probably *Metasequoia chinensis* (Endo) Hu should be also reduced to synonymy. Although it has been described to possess fewer cone-scales than *M. disticha,* the dimensions of its cones and cone-scales fall within the range of those of the living *M. disticha.* Since fossil specimens are usually poor and scanty, more collections are needed to verify the number of cone-scales in *M. chinensis.*

A comparison of the species of *Metasequoia* discussed above is given in Table I which shows that they probably should be all included under one single species, *Metasequoia disticha* (Heer) Miki. The description of this species may be amended as having leaves 8-15×1.2-2 mm. and cones 12-25×12-23 mm., with 12-24 scales

measuring 3-9×7-21 mm. Hu and Cheng (4) list several other fossil species of *Sequoia* under the genus *Metasequoia*, attributing the new combinations to Chaney. These are not included in the present comparison.

TABLE 1. COMPARISON OF SPECIES OF METASEQUOIA

Species	Size of cones mm.	No. of cone scales	Size of cone-scales mm.	Size of leaves mm.	Source of data
M. disticha	15–20 x 15–20	16–20	3–5 x 11–14	12 x 1.5	Miki (7)
			3 x 10		Miki (6)
	23 x 20	20	5 x 13		Endo (2) on *S. Onukii*
	16 x 16	16	3 x 10	10 x 2	Endo (2) on *S. japonica*
	12 x 12	12–16	4–5 x 10–11		Miki (7) on *M. japonica*
	12–23 x 12–20	12–20	3–5 x 10–14	10–12 x 1.5–2	Summarized data
M. chinensis	22 x 22	10	7 x 15		Endo (1)
M. glyptostroboides	18–25 x 16–23	22–24	7–9 x 18–21	8–15 x 1.2	Hu et Cheng (4)
	19–23 x 17–22	16	3–6 x 7–18	8–15 x 1.3–2	co-type at Inst. Bot.
	18–25 x 16–23	16–24	3–9 x 7–21	8–15 x 1.2–2	Summarized data

Regarding the systematic position of the genus *Metasequoia*, opinions vary but little. As already mentioned, Miki (7) places the genus in the Taxodiaceae. Hu (3) has expressed the view that the general aspects of *Metasequoia* are those of *Glyptostrobus-Sequoia-Taxodium* complex and the genus should be regarded as a member of the Taxodiaceae. Liang et al (5), having made a special anatomical study, concludes that the wood of *Metasequoia* agrees most closely with those of the Taxodiaceae. The raising of the genus *Metasequoia* to family rank by Hu and Cheng is not a matter of variation in opinion concerning the systematic position of the genus. It is merely a matter of difference in treatment.

Since *Metasequoia* has the general aspects of the Taxodiaceae and, on the other hand, the decussate arrangement of its vegetative and floral organs shows relationship with the Cupressaceae which is phylogenetically a more advanced family than the Taxodiaceae, this genus serves as a link connecting the two families. But this does not make it necessary to raise the genus to family rank. It might well be regarded as the most advanced genus in the family Taxodiaceae. To place a genus with cyclic arrangement of parts in a family with spiral arrangement is not without precedent. The genus *Microcachrys* in the family Podocarpaceae is a well known case.

If the above view were to be accepted, the present status of *Metasequoia disticha* would be as follows:

TAXODIACEAE

METASEQUOIA Miki

M. DISTICHA (Heer) Miki, Jap. Jour. Bot. 11:262, pl. 5, A-Ca; fig. 8, A-G. 1941.

Sequoia disticha Heer, Flora Fossilis Arctica 4:63. pl. 12, fig 2a; pl. 13, figs. 9-11. 1876.
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A NEW SPECIES OF ZYGNEMA

CHIN-CHIH JAO

ZYGNEMA CUCURBITINUM, sp. nov. (Fig. 1)

Z. filamentis vegetativis tegumento gelatinoso amplo hyalino involutis; cellulis vegetativis 32—35 μ latis, 25—63 μ longis, plerumque diametro paululum longioribus; conjugatione scalari; zygosporis in tubo conjugationis et in gametangia extentis, transverse elongatis, cylindraceo-oblongis, apice rotundatis, medio plerumque leviter constrictis, 25—30 μ latis, 83—92 μ longis, membrana triplici: mesosoporio minute scrobiculato, maturitate brunneo.

Szechwan: near the Hot Spring Park, Pehpei, *SC1101*, (TYPE, Herb. Inst. Bot., Acad. Sinica), Dec. 3, 1939, in rice fields, abundant.

Numerous conjugating filaments of this species were obtained by the writer. Both young and mature zygospores are always cylindric-oblong in shape passing transversely from one gametangium through the conjugation tube to the other. The peculiar shape of the zygospores is a very conspicuous character, which distinguishes this species from all previously described members of this genus.

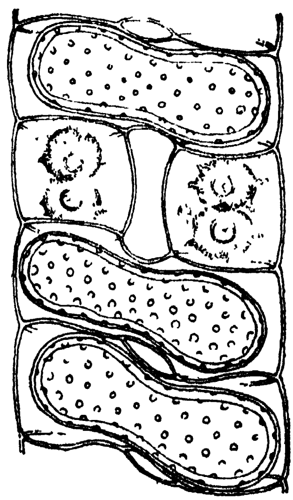

Fig. 1. *Zygnema cucurbitinum* Jao, sp. nov. X 410.

CULTIVATION OF EXCISED PLUMULES OF NELUMBO SPECIOSUM IN VITRO

TA-CHU LIU

The embryo of *Nelumbo speciosum* Willd. is composed of a well developed green plumule and two large white fleshy hemispherical cotyledons united at the base and with two coiled awe-shaped leaves lying between them. The plumule is enclosed by a thin membrane of endosperm.

According to Rendle (9), the radicle of the embryo is functionless, its place being taken by adventitious roots developed on the plumule. The writer attempts to cultivate the plumule in vitro to induce its rooting, and to see the chlorophyll development in further growth.

METHODS

Selected seeds of *Nelumbo speciosum* from fruits collected in 1947 were soaked in tap water about 12 hours, then immersed in 0.1% alcoholic sublimate solution for 4-5 minutes, and finally washed five times with sterilized distilled water. The broken seeds were discarded. Each seed was put in a Petri dish and one of the cotyledons was removed (Fig. 1). Then the thin membrane of endosperm was unclothed and the plumule was cut slightly above its attachment to the cotyledons. The plumule with length about 1.5 cm. was detached from the cotyledon and transferred into culture solution. This operation was carried out in an aseptic room.

White's solution with 2% sucrose and 500 ppm. yeast extract was used as the culture medium (14). All chemicals were of Merck's. Distilled water was first treated with animal charcoal, then filtered. The Erlenmeyer flasks of 100 or 150 cc. made of hard or Pyrex glass were used as culture vessels. They were plugged with cotton and sterilized in electrical dry oven above 100°C about 15 minutes. After each flask was filled with 50 cc. culture solution and its plug was wrapped with paraffin paper, all the preparations were sterilized in autoclave under 15 pounds steam pressure about 15 minutes. All other apparatus were sterilized in dry oven.

The experiments were divided into two sets: (1) under diffused light, with room temperature about 22-26°C, and (2) in darkness, with room temperature about 22-24°C. The experiments were carried out from May to July. The number of cultures were 200. Under diffused light, the room temperature fluctuated widely, while in the dark, it was lower and less variable.

Each culture was observed daily for the growth of leaf petioles and the development of chlorophyll and of roots. The linear measurements were approximately carried on (14). All the examinations of the cultures in darkness were done under red light. The experiment was repeated.

RESULTS

Under diffused light, the important features of the growth of the excised plumules observed are as follows: On the second day of the experiment, the two green plumule leaf petioles began to unbend. On the third day, the petioles seemed to start to elongate, and the elongation became evident on the seventh day. On the ninth day, rooting at the base of the first petiole, or strictly speaking, the first node of the

plumule, began to take place in several cultures. On the twelfth day, the petioles of the third leaves, following those of the first and second leaves, appeared. On the fourteenth day, roots on the first node prevailed in cultures. On the seventeenth day, rooting started on the second plumule node. On the twenty-first day, the growth of the first petioles which are now about 3-4.5 cm. long, began to slow down; the second ones about 1-3.5 cm. long, had ceased to grow; the third ones, about 5-9 cm. long and with one bract at the base, had made rapid growth; and the roots on the first node reached 3.5-7.5 cm. in length. On the thirty-third day, the fourth leaves came forth with a bract also, and the third leaves expanded to about 1.5 cm. in diameter and became peltate on slender petioles. On the thirty-fifth day, the plumules attained considerable size (Fig. 2), and a few leaves started to rot which were still awe-shaped regardless whether they had been immersed in solutions or not.

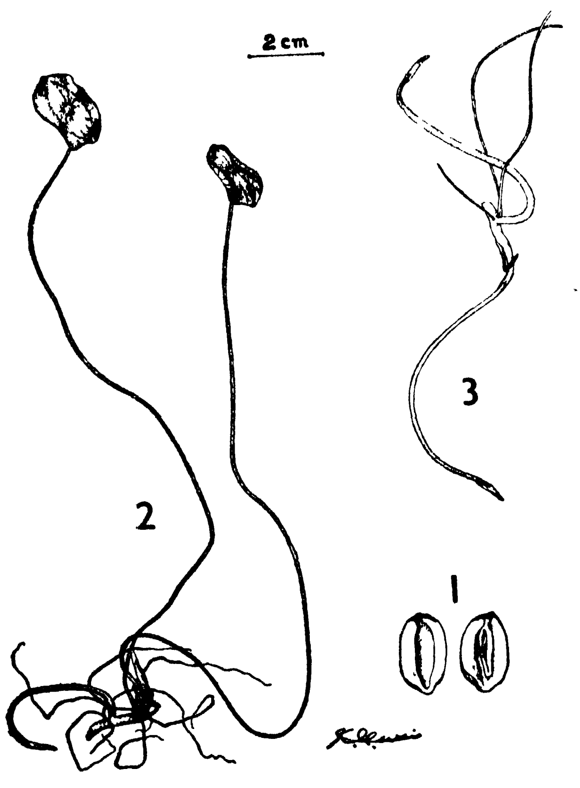

Fig. 1. The embryo showing one cotyledon removed and the other with attached plumule.
Fig. 2. The plumule growing under diffused light for 34 days.
Fig. 3. The plumule growing in darkness for 34 days.

In darkness, the growth features observed on the first six days were similar to those under light. But on the seventh day, the petioles elongated slowly, and lacked the green color especially near the bases. On the twelfth day, the petioles of the first three leaves had appeared in succession. On the fourteenth day, the bases of the petioles of the first two leaves were very pale. Rooting on the first nodes started on the seventeenth day, with few exceptions. On the twenty-first day, the length of petioles of the first three leaves reached 2.5-6 cm., 0.6-1.5 cm., and 0.2—0.5 cm., respectively; and the roots on the first nodes were 1.5-7.5 cm. long. The third leaves were then awe-shaped, red, with very pale petioles. On the thirty-fifth day, the growth of plumules was very much less than those under light; no leaf expanded and no rotten leaf appeared (Fig. 3).

Briefly speaking, in both sets, roots were produced on each side of the petiole, 1-4, generally 2, in number, rarely with rootlets; the slender petioles and sheath-like bracts were started from the third nodes; the internodes were short; and the general features of the plants were more or less abnormal due to varied geotropic adaptation

to fluid media such as torsion and twist, and to the limitation of space in the containers. But in darkness, the growth rate of any part of the plant was usually less than that under light, and the chlorophyll failed to develop on the growing parts except on the first two plumule leaves.

DISCUSSION

There are few records regarding the successful cultivation of excised shoot tip *in vitro* as compared with the culture of root tips. As to rooting on the stem, the writer attempts to review the works during the past few decades on the cultivation of isolated stem tips, that are available to him. Robbins (10) was the first to succeed in growing excised stem tips in modified Pfeffer's solution plus glucose. White (13) cultured the shoot tips of *Stellaria media* in a balanced salt solution plus dextrose and yeast extract for 3 weeks, and found differentiation of stems, leaves and floral organs. Dawson (3) working with excised leafy shoots of tobacco found that low temperature was not harmful to the excised stems for absorption of solutes. Loo (5,6) who cultured the stem tips of *Asparagus officinalis,* found that the tissue exhibited unlimited growth in light but not in darkness, and neither the cultures in light nor those in darkness produced any trace of root at all. The same author (7) performed further experiments with stem tip of dodder *(Cuscuta capestris),* and found the production of lateral buds and flowers without the formation of leaves and roots. None of the above mentioned authors succeeded in producing roots.

Smith (12), who studied the effect of various accessory growth substances——yeast extract, vitamin B_1, and 3-indole acetic acid—on the growth of excised stem tips of *Helianthus annuus,* found that roots developed in some of the cultivated stem tips, and the accessory substances applied were favorable to the root growth. Reano (8), who treated stem tip cuttings of coffee with various liquid preparations, found that the phloem and the cambium which were associated with the initiation of root primordia were most responsive to the synthetic growth substances. Ropp, (11) culturing stem tips of rye found that roots developed on isolated stem when sucrose was present. Ball (1, 2) culturing the shoot apices of *Tropaeolum majus* and of *Lupinus albus,* obtained the production of adventitious roots in *Tropaeolum majus,* but not in *Lupinus albus.* Most recently, Galston (4) reported that excised asparagus stem tips formed roots readily when exposed to appropriate concentrations of indole-acetic acid in the dark.

From the various works above mentioned, it seems obvious that accessory growth substances might be very helpful in root production, but are not always necessary Perhaps, the rooting on stem is a matter of specific character. Some species produce roots easier than others. The different potentiality of rooting may be due to different capacity of differentiation of the meristematic tissues in the stem, and gives rooting at definite position, such as nodes.

As indicated by some authors, root formation in the culture of excised shoot tips *in vitro* occurs only in light. The results of the present work show that it is not the case. Indeed, the excised plumule grew and produced root more vigorously and more rapidly in light than in the dark. But these may be accounted for by the occurrence of photosynthesis and production of root-forming material such as rhizocaline in the presence of sunlight. The development of roots in the excised plumule of

Nelumbo speciosum in the dark indicates that light is not a limiting factor for root formation on excised shoot tips *in vitro.*

SUMMARY

Excised plumules of *Nelumbo speciosum* were cultured in White's solution under sterile conditions. It was found that roots were produced on the node regardless the cultures being kept under light or in the dark.

The excised plumule and root grew more vigorously in light than in the dark.

The writer is deeply grateful to Dr. T. L. Loo, Director of the Institute, for his direction and criticisms.

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TREE RINGS AND CLIMATE IN KANSU

S. C. Teng

Literature dealing with the relation of tree rings to climate is voluminous. Since 1914, many investigators have made attempts to compare the tree growth with rainfall for the purpose of establishing a basis upon which past rainfall could be derived and future rainfall predicted.

Among the workers who claim to have found a direct record of rainfall in tree rings, Douglass (6) has furnished the greater part of the evidence of rainfall cycles in tree growth, which show striking correspondence with the sun-spot period. These claims have a wide popular appeal, since a knowledge of rainfall cycles, if they do exist, will permit the taking of necessary precautions against the disasters due to drought as well as flood, and will be very useful in the economic management of farms and forests (4). In these works, interpretation of the results of analyses of growth rings has been based primarily on the assumption that every sharply bounded growth layer, as seen commonly under a hand lens, constitutes an annual increment, and that variations in the width of growth rings correspond to variations in rainfall, a thick ring indicating a wet year and a narrow one a dry year. The so-called "cross-dating" has been employed whereby the variations in the growth-layer sequence of one tree are matched with those in another tree. Trees which do not cross-date are often discarded. The best known cycles so far found is the 11-year cycle and its multiples or fractions. They are 2-3, 5-6, 10-13, 21-24, and 100-105 years, corresponding approximately to quarter sun-spot, half sun-spot, full sun-spot, double sun-spot, and triple-triple sun-spot periods respectively.

Many other workers (2, 3, 10, 11), however, have obtained results which are either indifferent or negative, i.e., they have found tree rings fallible as records of climate, or simply bearing no direcct relation to rainfall and sun-spots. This is not at all surprising. In the light of present ecological and physiological principles, the width of each annual ring represents a summation of the effects of all the factors influencing tree growth, as soil, topography, light, air temperature and humidity, nature and distribution of precipitation, competition, defoliation, seed production, root development, food reserves, cambial activity, etc. The complexity, the interaction, and mutual dependency of these factors are so well known as to require no further emphasis.

Thus the question is raised as to how accurately tree rings reflect rainfall. Obviously, just a small percentage of the fluctuation in tree growth is due to the amount of rainfall, and a tree will not record rainfall which does not influence its growth. Glock (7) has made an impartial review of the whole situation.

The present paper deals with the attempt of the writer to find cycles in the growth of trees in Kansu and their correlation with the sun-spot period and also with the occurrence of critical droughts recorded in local historical writings. Unfortunately, no rainfall data from the localities where materials for the present study have been collected, are available for comparison.

METHODS AND RESULTS

During the course of the writer's work on stem analysis of Kansu trees, a transverse section of the trunk at 10-ft. point above the ground was taken from each selected tree.

From each section, a V-shaped cut was selected from a quadrant which showed no evident abnormality in growth, and preserved for the present study. The trees were chosen on the basis of their location and normality of development of rings. They were all apparently dominant and growing on slopes of about 30 degrees at altitudes about 2,200 meters above sea level. Three samples were taken from the Heiho valley in Kilien-shan where the annual precipitation is probably about 15 inches, and one from Peilungkiang valley near Siko where the rainfall amounts approximately to 25 inches per annum. The three samples from Kilienshan all belong to one species, *Picea asperata* Mast., which is a moderate light-demander. The trees from which the samples were taken, were located about 20 miles apart from one another. The sample from Peilungkiang belongs to *Abies chensiensis* Van Tiegh. which is more tolerant than *P. asperata*.

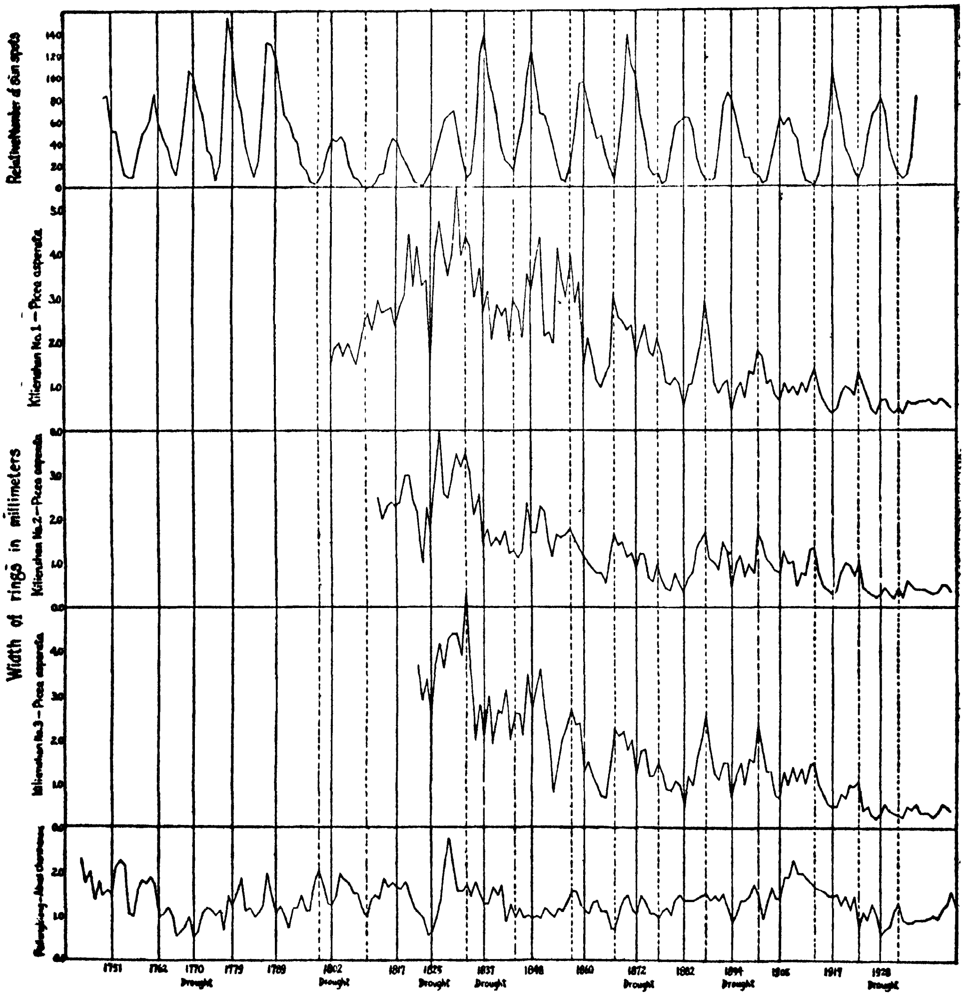

Fig. 1 Tree rings in comparison with sun spots and known droughts in Kansu

Only one radius was selected from each sample. Measurements were made by means of a wide-field magnifier and a ruler graduated in half-millimeters. Readings were taken from the ruler placed against the wood. These measurements are subject to the errors of estimating tenths of a millimeter, but such errors do not appear to play a significant part in the present work. No effort has been made in cross-dating, but the rings in the different trees studied seem to cross-date naturally. The original, unstandardized, and unsmoothed data have been used in plotting graphs. These are compared with the curve representing the relative number of sun-spots, derived from the data given by Abetti (1).

From an analysis of the ring variations in terms of cycles, there seems to be a fairly close correlation between the sun-spot period and the cycles shown in tree rings. The latter are predominantly 11 to 12 years in length, corresponding to the full sun-spot period. Within each cycle there seem to be smaller cycles of irregular length, equivalent to the quarter sun-spot period of 2 to 3 years or its multiples. Though sometimes occurring one or two years earlier, the sun-spot maxima correspond quite well with the narrow rings in trees, except in 1825 when the tree minimum is not accompanied by a sun-spot maximum. Interestingly enough, the tree minima of 1770, 1802, 1825, 1837, 1872, 1894, and 1928 likewise coincide with times of drought known in the history of Kansu. Not only the minima in the growth cycles of trees seem to bear a relation to the maxima of the sun-spot cycles and, in several cases, to the occurrence of known droughts, but the maxima in tree rings also match quite closely with the sun-spot minima. All such correlations are rather striking in all the samples from Kilienshan, but they are less definite in the sample from Peilungkiang. The results of the analysis of variations in growth rings are shown in Figue 1.

DISCUSSION

Although in the present work only four trees have been studied, it is interesting to find that in all of them there are apparent cycles coinciding fairly closely with the sun-spot cycle, and that such coincidence, in general, agrees with the results of many European and American studies. The marked resemblance in the growth-ring sequence among the trees collected over a wide territory in which climate appears to be the only common factor, leads one to believe that under certain conditions climate actually has some relation with the variations of widths of tree rings. But it does not seem to warrant the assumption that rainfall alone is responsible for such variations which in all probability may be due to more than one climatic factors. Hansen (8) found that constant prevailing winds, snow-shear, and a short period of favorable temperature were the chief limiting factors for maximum growth of Engelmann spruce near timberline. The same author (9) also found that the low summer rainfall and the high temperature in central Washington seemed to be the dominant limiting factors which prevent normal growth of conifers.

Proper selection of trees, as emphasized by Douglass (6), deserves special attention. A few trees properly selected with reference to topographic location, water supply, and relation with other trees, may yield more desirable results than many trees carelessly selected.

Unfortunately, too few samples have been collected especially from Peilungkiang; and there is no sample from young trees, so that reliable record of ring variations from

the year 1923 on is unavailable due to congestion of recent rings in older trees. Alternation of wide and narrow rings since 1923 is rather indefinite, especially in the samples from Kilienshan.

Prior to 1923, the correlation of the tree rings with the sun-spot cycle is more striking in all of the Kilienshan samples than in the Peilungkiang sample. This seems to be due to the fact that climatic conditions in Kilienshan are less favorable for tree growth than in Peilungkiang, and that *Picea asperata* is less tolerant than *Abies chensiensis*. It seems natural to expect that where climate actually becomes the limiting factor in tree growth, cycles in the growth of trees, if such were really present and directly related to climate, would be more evidently shown; and it is generally conceded that growth-rings of light-demanding trees correlate more readily with climate (5).

As a matter of fact, unless reasonably dependable meteorological records are available for comparison with ring variations, the real relation between tree growth and climate cannot be ascertained. The relation between tree rings and sun spots should be tentatively considered as mere coincidence, since there are exceptional cases where there is no correlation between the two. Owing to our present incomplete knowledge of the complicated growth factors and growth processes, interpretations are necessarily premature. Further investigations should be undertaken on the basis of ecological and physiological principles. While in certain localities, as in Kilienshan, ring variations may be directly or indirectly caused by climatic conditions, it is unjustifiable to ascribe them to rainfall alone.

The writer is indebted to Dr. Y. C. Chang, Director of the Institute of Astronomy, Academia Sinica, for copying the sun-spot data for him.

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FLOWERING PLANTS OF NORTHWESTERN CHINA, II.

CHIEN P'EI

BETULACEAE

Deciduous trees or shrubs, with various colored bark and ways of exfoliation; buds with few scales; leaves alternate, petioled, usually straight veined, stipules present, usually caducous, flowers unisexual, monoecious, rarely dioecious, staminate flowers in catkins, usually appearing in autumn and opening the next spring, stamens 2 13 to each bract, with or without calyx; pistillate flowers in catkin or cone shaped and spike like; ovary 2 celled, with 2 pendulous ovules in each cell, styles 2, usually persistent, fruit a 1 seeded nut; seeds exalbuminous.

Six genera with about 100 species in the temperate and colder regions of the North Hemisphere.

In our herbarium, the preserved specimens from Northwestern China represent four genera, among which the differences are given in the following key

1 Nuts small, compressed and winged, 2 3 in axils of scales forming catkins, stamens 2 4, with 2 4 parted calyx *Betula*

1 Nuts large, not compressed and winged, usually enclosed in a foliaceous involucre forming spikes or clusters stamens 3 13, without calyx 2

2 Fruit in pendulous slender spikes, buds elongated acute, stamiaminate flowers inclosed in scaly buds, leaves with 9 or more pairs of veins *Carpinus*

2 Fruit in clusters, buds ovoid, obtuse or acute, staminate catkins naked during winter, leaves ovate or orbicular ovate with usually 5 8 pairs of veins *3.*

3 Anthers undivided flower with the leaves nut small, enclosed by the tubular involucre, with 3 fid apex *Ostryopsis*

3 Anthers divided flower before the leaves nut large, wholly or partly enclosed by a leafy involucre, with laciniate apex *Corylus*

BETULA Linnaeus

Deciduous trees or shrubs, buds with several imbricate scales, leaves petioled, usually ovate, doubly serrate or dentate to lobulate, with few to many parallel lateral weins; flowers monoecious, staminate catkins elongated, formed in autumn and remaining naked during winter, every bract with flowers, each flower with a minute 4-parted calyx and 2 stamens, each stamen divided at apex; pistillate catkins cylindric or subglobose to oblong, each bract with 3 flowers, without calyx; fruit a minute nut, usually with menbranaceous wings, at maturity droping together with the 3-lobed bract from the slender rachis.

About 40 species in North Hemisphere, considered as valuable timber wherever they occur.

1. Leaves with 7 or more pairs of veins, usually more or less impressed above 2

1 Leaves with 3 7 pairs of veins, rarely 8, usually not impressed above 8.

2 Strobiles cyclindric to subcylindric *3.*

2 Strobiles elliptic-oblong or subglobose *5.*

3 Bark dark brown, branchlets glandular and villous, leaves ovate, with veins deeply impressed above, the middle lobe of bracts dilated above the middle ***B utilis.***

3 Bark bright orange-red or orange brown to brown, leaves usually ovate oblong, with veins not conspicuously impressed; the middle lobe of bracts slender and tapering *4.*

4. Bark bright orange to orange red, branchlets glabrous, sometimes glandular; leaves often ovate-oblong, usually glabrous or slightly pilose on both surfaces and sparsely glandular or sometimes with tufts of hairs beneath *B. albo-sinensis.*
4. Bark orange-brown to brown, branchlets more or less glandular; leaves ovate-oblong, with denser silky hairs on vein and tufts of hairs beneath *B. albo-sinensis* var. *septentrionalis.*
5. Leaves large, 5-14 cm long, oblong-ovate, acuminate; wings of fruit ½ as broad or as broad as nutlet *B. costata*
5. Leaves small, 2 7 cm long, ovate or elliptic-oblong to elliptic, acute; wings of fruit very narrow 6.
6 Leaves ovate, acute, with 7-10 pairs of veins *B. chinensis.*
6. Leaves oblong-elliptic to elliptic, acute, with 10-22 pairs of veins 7.
7. Lateral veins 14-22, very prominent beneath, usually with white and rufous-tomentose, with long rufous hairs on veins beneath; teeth acute; bracts of strobile not long ciliated *B. Potanini*
7. Lateral veins 9-14, prominent beneath, long-haired on veins beneath, bracts of strobile long-ciliated *B. Delavayi.*
8. Usually trees, leaves large, 3 6 cm long, strobiles cylindric 9.
8. Usually shrubs, leaves small, 1-2 cm long, strobiles oblong *B. sibirica.*
9. Bark white, bracts of strobile with lateral lobes spreading or recurved, usually longer than the middle lobe *B. mandshurica.*
9. Bark brown; bracts of strobile with the lateral lobes suberect, shorter than the middle lobe *B. davurica.*

BETULA UTILIS D. Don var. PRATTII Burk., Jour. Linn. Soc. Bot. 26: 499. 1899.

Tree up to 20 m. tall; bark grayish-brown to brown; branchlets villous and glandular; leaves chartaceous, ovate, rarely narrow ovate, acuminate at apex, rounded at base, irregularly serrate, glabrous or slightly pubescent above, pilose with tufts of hairs beneath, 5-9 cm. long, 2.3-6 cm. broad; veins 10 or more pairs, conspicuously impressed; petioles 1-2 cm. long, glabrous, glandular; strobiles peduncled, cylindric, suberect; bracts glabrous, sparsely glandular, shortly ciliate, the middle lobe much longer than the lateral ones and dilated above the middle, with lateral lobes more or less spreading and spathulate; nutlets puberulent at upper part, with wings half as the nutlet.

Szechuan: Without precise locality, *C. W. Yao 3119* and *3124.*

Distrib.: Also reported in Sikang.

BETULA ALBO-SINENSIS Burk., Jour. Linn. Soc. Bot. 26: 497. 1899.

Betula utilis Burk., Jour. Linn Soc Bot 26: 499 1899, pro part, non D Don

Betula Bhojpattra var. *sinensis* Fr, Jour. de Bot. 13: 207. 1899.

Betula utilis var *sinensis* Winkler, Engler Pflanzenr 4 (61). 62 1904

Tree up to 30 m. tall; bark bright orange to orange-red; branchlets slightly glandular; leaves ovate oblong, irregularly serrate, acuminate at apex, rounded or sub-cordate at base, sparsely pilose on veins above, sparsely glandular and slightly pilose on veins or rarely with tufts of hairs beneath, 4-7 cm. long, 2.5-4 cm. broad; veins 8-12 pairs; petiole about 1 cm. long, glabrous or slightly pilose; strobiles 4 cm. long, with middle lobe of the bract twice as long as the lateral spathulate ascending lobes; wings of nutlet equal or wider than nutlet.

Kansu: Towho, *C. K. Chow,* June-Oct. 1946.

Distrib.: Also recorded in Northern and southwestern China.

This species is easily distinguished in the field from its allies by its bright orange to orange-red bark exfoliating in flakes.

BETULA ALBO-SINENSIS Bark. var. SEPTENTRIONALIS Schneid., Sargent's Pl. Wilson. 2: 458. 1916.

Tree up to 35 m. tall; bark dull orange to orange-brown; branchlets glandular; leaves oblong-ovate, irregularly serrate, shortly acuminate at apex, rounded or subcordate at base, 5-9 cm. long, 2.5-4.5 cm. broad, sparsely pilose above, densely pilose on veins with axillary tufts of hairs beneath; veins 10-14 pairs; petioles 5-15 cm. long; strobiles cylindric, 2.5-3.5 cm. long, with linear-oblong middle lobe of the bract which is longer than spreading-erect lateral lobes.

Kansu: Towho, *C. K. Chow 17* and *25*, June-Oct. 1946.

Distrib.: Also in Hopei, Shansi, Shensi and Szechuan.

This species is very much like *Betula utilis* var. *Prattii* Burk., from which it is differed by its ovate-oblong leaves with veins not impressed on the upper surface and by its bark not so dark in color as the latter. These two species need further observation in the field. Ample collection of specimens may prove that they are the same.

BETULA COSTATA Trautv., Mem. Sav. Etr. Acad. Sci. St. Petersb. 9: 253 (Maxim., Prim. Fl. Amur.). 1859.

Betula Ermani var. *costata* Regel, Nouv. Mem. Soc. Nat. Mosc. 13 (2): 123, t. 13, fig. 1-6 (Monog. Betulac. 65). 1861.

Betula ulmifolia var. *costata* Regel, Bull. Soc. Nat. Mosc. 38 (2): 414. 1865.

Betula ulmifolia Dippel, Handb. Laubholzk. 2: 188. 1893, pro parte.

Tree up to 30 cm. tall; bark grayish brown, exfoliating in flakes; branchlets glabrous, brown, villous when young; leaves ovate to oblong-ovate, long-acuminate at apex, rounded or subcordate at base, finely and doubly serrate with acuminate teeth, sometimes sparsely pubescent and pilose on veins above, glandular and densely pilose on veins beneath, 5-8 cm. long, 2-4.5 cm. broad; veins 10-16 pairs; petioles 8-15 mm. long; strobiles ellipsoid, about 2 cm. rarely 3 cm. long, short-stalked, with middle lobe of bracts about twice as long as the ovate or obovate somewhat spreading lateral ones.

Hopei: Peihua-shan, *Y. Yabe*, June 26-27, 1905; July 29, 1905.

Distrib.: Manchuria and Korea.

BETULA CHINENSIS Maxim., Bull. Soc. Nat. Mosc. 54: 47, pt. 1. 1879.

Betula exalata S. Moore, Jour. Linn. Soc. Bot. 17: 386, t. 16, fig. 8-10. 1879.

Betula chinensis var. *angusticarpa* Wingler, Engler Pflanzenr. 4 (61): 67, fig. 19, K-L. 1904.

Shrub or small tree; bark grayish; branchlets brown, villous while young; leaves ovate, unequally serrate, with mucronulate teeth, acute at apex, rounded at base, pilose on midrib above, pilose on veins beneath, 2-6 cm. long, 1.5-4.5 cm. broad; veins 8-10 pairs; petioles 4-8 mm. long, densely pilose; strobiles ellipsoid, 1.5-2 cm. long; bracts with middle lobe lanceolate, ciliate, acute at apex, and the lateral ones 2-3 times shorter than middle lobe or reduced; wings of nutlet very narrow.

Liaoning: Tsaoho-kou, *Y. Yabe*, Aug. 28, 1909.

Hopei: Peihua-shan, *Y. Yabe*, July 16, 1908.

Shansi: Without precise locality, *C. D. Reeves*, Summer 1926, new record.

Distrib.: Common in northeastern China and also in Korea.

This species is markedly different from other Chinese species by the very narrow wings of its nutlet and reduced lateral lobes of the bract. The province Shansi may be the western limit of this species.

Betula sibirica (Ledeb.) P'ei, status nov. Fig. 1.

Betula nana Ledeb. Fl. Alt. 4: 246. 1833, excl. syn.

Betula rotundifolia Spach, Ann. Sci. Nat. ser. 2, 15: 194. 1841.

Betula nana var. *sibirica* Ledeb. Fl. Ross. 3 (2): 654. 1850; Regel, Nouv. Mem. Soc. Nat. Mosc. 13: 101, t. 9, fig. 9-12, 14-18 (Monog. Betulac.). 1861.

Chamaebetula rotundifolia Opiz, Lotos Jahrb. Nat. 5: 259. 1855.

Betula glandulosa var. *rotundifolia* Regel, Bull. Soc. Nat. Mosc. 38 (2): 408. 1865.

Betula glandulosa Wingler, Engler Pflanzenr. 4 (61): 73. 1904, non Michaux, quoad specimina asiat.

Betula glandulosa var. *sibirica* (Ledeb.) Schneid., Sargent's Pl. Wilson. 2: 481. 1916, syn. nov.

Shrubs with brown bark; branchlets resinous-glandular, shortly pubescent when young; leaves orbicular or broadly oblong, usually broader than long, coarsely rounded-toothed, pubescent on veins and sparsely glandular above, glabrous and glandular dotted beneath, 1-1.3 cm. long, 0.9-1.6 cm. broad, with 3-4 pairs of veins; petiole short, 3 mm. long, pubescent; strobiles oblong, about 1.2 cm. long; shortly peduncled; bract trilobed at upper portion, lobes equal in length, ciliate, lateral lobes erect; nutlets glabrous, broadly winged, with wings equal to or broader than the nutlet.

Sinkiang: Chenghua, Sung-k'e-mu-ta-pan, *C. Lin 269.* Chenghua, Tung-ch'a-ho-ta-pan, *C. Lin 316.* Chenghua, Hung-shan-tsui-tsu, *C. Lin 322.*

Distrib.: Also in Eastern Siberia.

This species was wrongly identified by Ledebour as *Betula nana* or its variety. Spach considered it a new species and gave its name, *B. rotundifolia.* Recently Schneider and Rehder rightly put it as a variety of *B. glandulosa,* but they have not seen any authentic specimens. The specimens from Sinkiang collected by C. Lin show marked difference from the typical form, *B. glandulosa.*

This species is quite different from the *B. glandulosa* Michaux. The wings of the fruit of this species are broad, equal to or broader than the nutlet and the lobes of bract are equal in length; while *B. glandulosa* has the bract lobes not equal in length, the lateral lobes of bract are suberect and the wings of the fruit are very narrow, about one-fifth or less the width of the nutlet. The leaves of *B. sibirica* are usually broader than long, from orbicular to broad-oblong; while the leaves of *B. glandulosa* are usually broad-oblong. Basing on the comparison of these two species stated above, a change of the status of *B. sibirica* seems justified. According to the law of priority, "rotundifolia" is earlier than "sibirica", but the name "rotundifolia" is preoccupied in several cases. In order to avoid the complexity of names, "sibirica" is adopted for this newly changed status.

Betula Potanini Batal., Act. Hort Petrop. 13: 101. 1893.

Betula Wilsonii Bean, Kew Bull. Misc. Inform. 30. 1914.

Shrub often with prostrate branches, up to 4 m. tall; branchlets densely villous; bud-scales tomentose; leaves ovate-oblong to oblong, coriaceous, irregularly toothed, with acute teeth, 2-3.5 cm. long, 1-2 cm. broad, sparsely pilose on midrib above, tomentose and rufous-haired on veins beneath; veins 10-22 pairs, deeply impressed above; petioles pubescent, 2-4 mm. long; strobiles broad-ellipsoid, with obtuse bracts, the middle lobe longer than lateral suberect lobes, pubescent outside, subglabrous inside; nutlets nearly wingless, pubescent on apex.

Szechuan: Mt. Omei, in woods, *Y. Y. Ho 6366,* Aug. 25, 1935, "Tree 4 m. tall."

Distrib.: Also in Sikang.

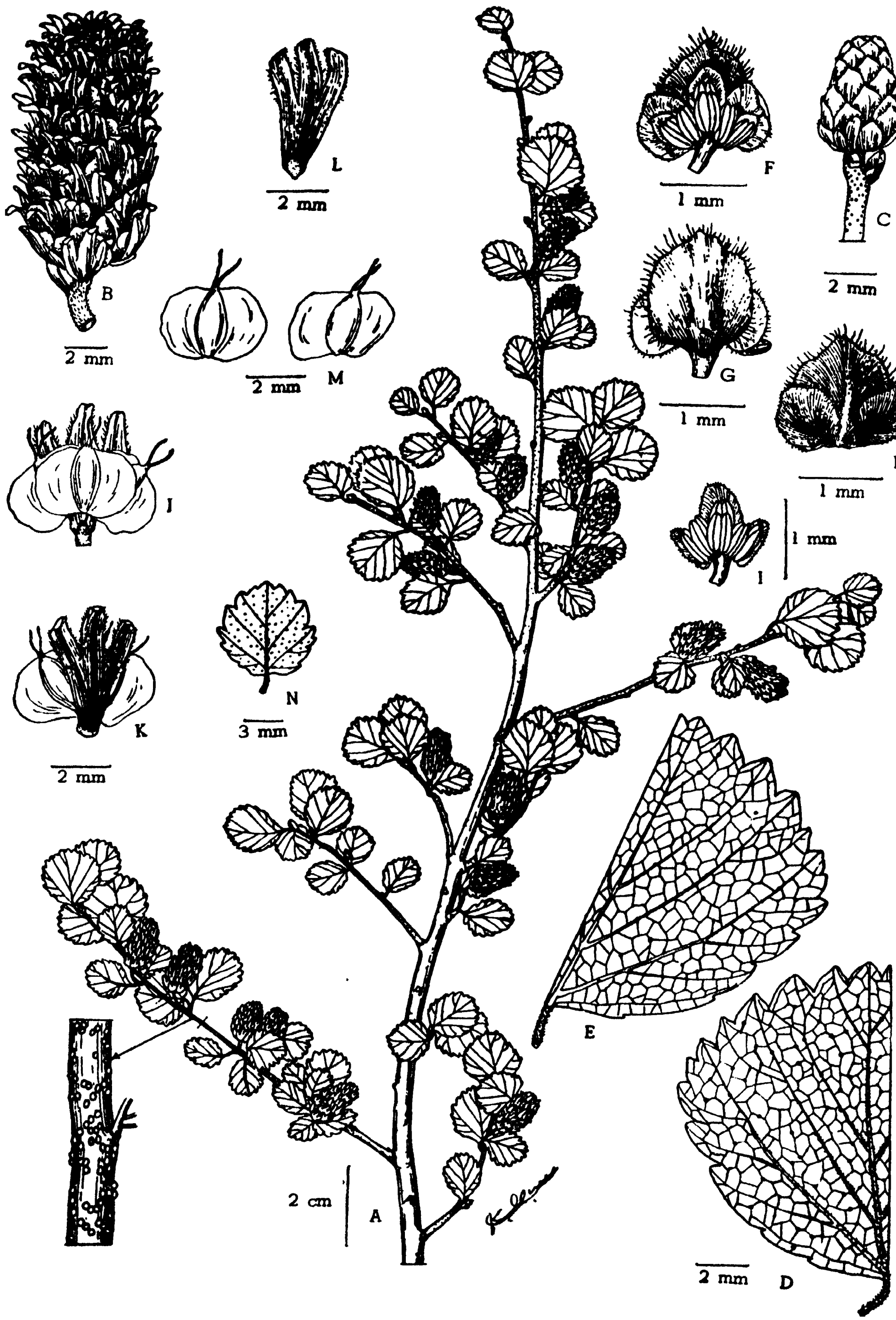

Fig. 1. *Betula sibirica* (Ledeb.) P'ei. A. Habit; B. Female strobile; C. Male catkin; D. Upper surface of leaf; E. Lower surface of leaf; F.-I. Male flowers in different views and parts; J.-K. Two views of fruits with bract; L. Bract; M. Fruits; N. Leaf.

BETULA DELAVAYI Fr., Jour. de Bot. 13: 205, 1899.

Betula chinensis var. *Delavayi* Schmidt, Ill. Handb. Laudholzk. 2: 884. 1912, pro parte.

Shrub or tree; bark of branchlets grayish-brown; bud-scales sparsely pilose; leaves elliptic to oblong-elliptic, irregularly toothed with acuminate teeth, 2-3.5 cm. long, 1-1.8 cm. broad, pilose on veins of both surfaces; veins 10-13 pairs, prominently impressed above; strobiles narrowly ellipsoid; bracts trilobed, with lobes slenderly long acuminate, longly ciliate, slightly pilose outside, glabrous inside, the middle lobe about twice as long as the suberect lateral lobes; nutlets very narrowly winged, pubescent at apex.

Kansu: Peilung-kiang, *C. K. Chow,* July-Oct. 1945.

Sikang: Without precise locality, *K. L. Chu 7666,* May 1948.

Distrib.: Also in Yunnan.

This species is similar to *Betula Potanini* Batal. from which it differs by its leaves with parallel lateral veins being not deeply impressed above and by the teeth of the leaf-margin being acuminate.

BETULA MANDSHURICA (Regel) Nakai, Bot. Mag. Tokyo, 29: 42. 1915.

Betula alba L. subsp. *mandshurica* Regel, Bull. Soc Nat Mosc 38: 399. t 7, fig 15 1865.

Betula latifolia sensu Komarov, Act Hort Petrop. 22: 38 (Fl. Mansh. 2). 1903, pro parte, non Tausch.

Betula japonica Sieb. var. a. *mandshurica* (Regel) H Winkler, Engler Pflanzenr. 4 (61): 78. 1904

Tree up to 20 m. tall; bark white; branchlets resinous glandular; leaves ovate, elliptic-ovate to deltoid-ovate, irregularly serrate, acute to short-acuminate at apex, truncate to broad-cuneate at base, sparsely pilose above, paler and pilose on veins or sometimes with axillary tufts of hairs and densely glandular dotted beneath, 4-6 cm. long, 2-3.5 cm. broad; petioles 1-2.5 cm. long; strobiles cylindric, pendulous, puberulent; the middle lobe of bract triangular, shorter or as long as the spreading broad lateral lobes; wings of fruit as broad as or broader than nutlet.

Kirin: Hsiopeh-shan, Y. *Yabe,* Aug. 6, 1918.

Liaoning: Hêk'eng-ling, Y. *Yabe,* Aug. 9, 1914. San-tao-kou, Y. *Yabe,* Aug. 12, 1917. Tsao-ho-k'ou, Y. *Yabe,* Aug. 20, 1917.

Shansi: S. Shansi, alt. 1750 m. in thickets along ravine banks, *T. Tang 826,* May 21, 1929, "30 feet high, bark gray, papery, peeling off showing the yellow bark, branchlets brownish, nearly smooth".

Distrib: From Korea to Manchuria and common in North China.

Of this species several varieties are separated by botanists basing chiefly on leaf characters. Their main differences from the typical form are given in the following key.

1. Leaves not subcordate, usually broadly cuneate or truncate at base ... 2.
1. Leaves usually subcordate or sometimes truncate at base ... var. *japonica.*
2. Leaves triangular ovate, usually truncate or sometimes broad-cuneate, thinner in texture ... var. *kamtschatica.*
2. Leaves usually broadly cuneate, thicker in texture ... 3.
3. Leaves usually glandular and with axillary tufts of hairs beneath ... *B. mandshurica.*
3. Leaves usually densely glandular and glabrous beneath ... var. *szechuanica.*

In this region, northwestern China, *Betula mandshurica* var. *szechuanica* is very common and occupies a zone from 4,500 to 10,000 feet.

BETULA MANDSHURICA (Regel) Nakai var. SZECHUENICA (Schneid.) Rehd., Jour. Arn. Arb. 19: 73. 1938.

Betula alba var. vulgaris Fr., Jour. de Bot. 16: 406. 1899. Burkill, Jour. Linn. Soc. Bot. 26: 497. 1899, non Spach.

Betula japonica var. *mandshurica* sensu Schneid., Sargent's Pl Wilson. 2: 461. 1916, non B. alba subsp. mandshurica Regel.

Betula japonica var. *szechuanica* Schneid., Sargent's Pl. Wilson. 3: 454. 1917. Rehd., Jour. Arn. Arb. 9: 24. 1928.

Tree up to 10 m. tall, with spreading branches; branchlets chestnut-brown, glandular-dotted when young; leaves ovate, broadly ovate, rhombic-ovate to triangular, irregularly serrate, glabrous, densely glandular-dotted beneath, acuminate at apex, usually broadly cuneate or truncate at base, 3.5-7.5 cm. long, 2.5-5.5 cm. broad, with 4-7 pairs of veins; petiole 1.5-2.5 cm. long, glabrous; strobiles cylindric, usually erect, about 3 cm. long; peduncle slender, pubescent, 1 cm. long; bracts of strobile trilobed, ciliate, puberulous on both surfaces, the middle lobe triangular-ovate, shorter or as long as the spreading broad lateral lobes; wings of nutlet as broad as or broader than nutlet.

Kirin: Without precise locality, *K. H. Chen 99*, 1930; *F. H. Chen, 497*, 1931.

Sinkiang: T'a-cheng, *C. Lin 78*, "Cultivated". Chenghua, K'a-la-er-ts'u-tsu-ho, *C. Lin 263*. Chenghua, Je-shui-chüan-kou-k'ou, *C. Lin 300*.

Hopei: Hsiaowutai-shan, T'eling-tze, *Y. Yabe*, Aug. 1, 1906. Peihua-shan, *Y. Yabe*, June 28, 1905.

Shansi: S. Shansi, alt. 1750 m., on slopes, *T. Tang 808*, May 20, 1929, "25 feet high, bark dark gray to Whitish". Mien-shan, Linshih-hsien, alt. 1200-2400 m., in thickets, *T. Tang 984*, June 5, 1929, "Tree, 4-30 feet, C.B.H. 1.5 feet, bark grayish white, smooth".

Kansu: Kilien-shan, *C. K. Chow*, July-Aug. 1945. Hinglung-shan, *C. K. Chow*, June 1945. Towho, *C. K. Chow* Aug. 1946. Hsiolung-han, *C. H. Hê*, May-Aug. 1945.

Distrib.: Common in N. E. Asia, Ussuri to Korea, also widely distributed from Northern China to Tibet and Yunnan.

This species is characterized by its whitish bark, rhombic-ovate leaves, which are glabrous and densely glandular-dotted beneath. As the flora of China being not thoroughly explored, it is difficult to delimit definitely the distribution of this variety as well as the typical form. This variety occupies a zone between 4,500 and 10,000 feet in Kansu and occasionally forms pure stands.

BETULA DAVURICA Pall. Reise 3: Note-321, 421, t. K. k, fig. 4, a-b. 1776.

Betula maximowiczii Rupr., Bull. Acad. Sci. St. Petersb. 5: 139. 1956; 15: 379. 1857.

Betula Maackii Rupr., Bull. Acad. Sci. St. Petersb. 15: 380. 1857.

Betula dahurica var. *maximowicziana* Trautv., Mem. Sav. Etr. Acad. Sci. St. Petersb. 9: 250 (Maxim. Prim. Fl. Amur.). 1859.

Betula wutaica Mayr, Fremd. Wald.-Parkbaume, 450, fig. 169. 1906.

Tree up to 20 m. tall; bark purplish brown, exfoliating in thin and small flakes; branches widely spreading; branchlets glandular pubescent, chestnut-brown; leaves narrowly ovate to rhombic-ovate, acute or shortly acuminate at apex, cuneate at base, irregularly dentate-serrate, pilose on both surfaces when young, finally glabrescent above, glandular-dotted beneath, 4-8 cm. long, 2.5-4 cm. broad; veins 6-8 pairs; petioles 5-15 mm. long, slightly pilose; strobiles trilobed, the middle lobe usually longer than lateral ones,

triangular in shape, lateral lobes rounded and spreading; wings of fruit about half or less than half as broad as nutlet.

Liaoning: Tsao-ho-kou, Y. *Yabe*, Aug. 20, 1917. Hek'eng-ling, Y. *Yabe*, Aug. 9, 1914. K'uan-tien, Y. *Yabe*, Aug. 13, 1917.

Distrib.: Common in Japan, also in Hopei province.

This species is very much similar to *Beula mandshurica* (Regel) Nakai, from which it is easily distinguished by the middle lobe of bract being longer than lateral ones.

CARPINUS Linnaeus

Deciduous trees or shrubs; bark gray, smooth or scaly; buds acute with many imbricate scales; branchlets slender; leaves more or less 2-ranked, with 2-24 pairs of straight lateral veins, usually double serrate; flowers opening in spring with the leaves; staminate catkins pendulous, inclosed in the bud during winter; flowers without perianth, each bract with 3-13 stamens 2-forked at apex; pistillate catkins terminal, slender, each bract with 2 flowers, each flower subtended by 2 bractlets; perianth adnate to the ovary, with 6-10 teeth at apex; style short, with 2 linear stigmas; fruit a ribbed nutlet subtended by a large bract.

About 30 species distributed in Asia, Europe, and North and Central America. We have a few species in Northwestern China. The wood is very hard and tough.

1. Bark smooth; leaves with 7-15 pairs of veins; bracts of staminate flower broad-ovate, subsessile; bracts of fruiting catkins chartaceous, ovate to lanceolate, not imbricate, slightly serrate on inner side; nutlet prominently ribbed .... 2.
1. Bark scaly; leaves with 15-24 pairs of veins deeply impressed above; bracts of staminate flower ovate-lanceolate, stipitate; fruiting bracts membranaceous, ovate, serrate, imbricate; nutlet not ribbed....3.
2. Leaves at maturity scarsely 5.5 cm. long, usually cordate at base..............*C. Turczaninowii.*
2. Leaves at maturity 6-11 cm. long, usually cuneate to broad cuneate at base........*C. Tschonoskii.*
3. Branchlets glabrous or slightly villous; leaves slightly villous on veins beneath...........*C. erosa.*
3. Branchlets pubescent; leaves densely pubescent and densely villous on veins beneath....*C. chinensis.*

CARPINUS EROSA Blume, Mus. Bot. Lugd.-Bat. 1: 308. 1850.

Carpinus cordata Bl. Mus. Bot. Lugd.-Bat. 1: 309. 1850.

Distegocarpus? erosa DC. Prodr. 16 (2): 128. 1864.

Distegocarpus? cordata DC. Prodr. 16 (2): 128. 1864.

Ostrya mandshurica Budischtschew, Zap, Sibirsk, Otd. I. Georgr. Obshche. 9-10: 461, 1867, ex. Trautv., Act. Hort. Petrop. 9: 166. 1884, fide Komarov.

? *Carpinus cordata*, f. *chinensis* Nakai, Jour. Coll. Sci. Tokyo, 31: 205. (Flor. Kor. 2.). 1911, non Franchet.

Trees up to 15 m. tall; branchlets and petioles densely pilose when young, soon glabrous; leaves oblong-ovate or rarely ovate, acuminate at apex, cordate at base, irregularly dentate-serrate, subglabrous above, sparsely pilose on veins beneath, 7-12 cm. long, 3.5-6.5 cm. broad; veins impressed above, 15-20 pairs; petioles 1-2.5 cm. long; fruiting catkins 6.5-10 cm. long, with puberulous rachis; peduncle slender, about 2.5-4 cm. long; nut oblong, glabrous, about 4 mm. long.

Kirin: Without precise locality, *F. H. Chen 499*, 1931.

Liaoning: Tsaoho-kou, Y. *Yabe*, Aug. 6, 1910.

Hopei: Eastern Tomb, *C. G. Li 10052*, 1929. Without precise locality, *H. T. Tsai 50287*, 1930.

Distrib.: From N. E. Asia southward to North China, and also recorded in Hupeh province.

Since *C. erosa* and *C. cordata* are identical, the name *C. erosa* is recognized because it has been published in the same book on a page earlier than *C. cordata.*

CARPINUS CHINENSIS (Fr.) P'ei, status nov. Fig. 2.

Carpinus cordata Bl. var. *chinensis* Fr., Jour. de Bot. 13: 202. 1899, non Nakai.

Carpinus cordata Winkl., Bot. Jahrb. 50: 489. 1914, pro parte.

Carpinus mollis Rehd., Jour. Arn. Arb. 11: 154. 1930, syn. nov.

Carpinus cordata Hu, Sunyatsenia, 1: 109. 1933, quoad specimina T. Tang 894. syn nov.

Trees up to 9 m. tall; bark grayish black; branchlets grayish, densely pilose when young or densely puberulous and subglabrous when mature; leaves oblong-ovate or slightly elliptic-oblong, acute to shortly acuminate at apex, cordate at base, irregularly serrate, sparsely pilose on veins above or on midrib only when mature, densely pubescent and densely pilose on veins beneath, 5-11 cm. long, 3-6 cm. broad; veins 14-24 pairs, conspicuously impressed; petioles up to 2 cm. long, densely pilose or puberulous; spikes 4-6.5 cm. long, with rachis densely pubsecent; peduncle pubescent; bracts 1.2 rarely 3 cm. long, dentate, pilose at lower part and on pedicels; fruit oblong, glabrous, smooth.

Shansi: Mien-shan, Lin-shih-hsien, alt. 1500 m., on slopes, *T. Tang 894,* May 30, 1929, "Small trees, 10 feet high, bark grayish black".

Kansu: Huangchialo-shan, *C. K. Chow 1160,* July-Oct. 1944.

Anhwei: Huang-shan, vicinity of Lingku-tze, along creeks, *Y. Y. Ho 2403,* May 20, 1934, "Tree, 7 m. high, bark grayish-white". From Wen-su-yuang to Shu-tsu-ling, *H. T. Liu,* Aug. 14, 1936.

Chekiang: Tienmu-shan, *C. Shen 403,* Oct. 7, 1934; *H. Migo,* May 14, 1935.

Szechuan: Sungpan-hsien, side of stream, *W. P. Fang 4245,* Aug. 17, 1928, "Tree about 9 m. high", type of *Carpinus mollis* Rehd.

Distrib.: Also in Honan and Hupeh provinces.

This species is formerly considered as a variety of *Carpinus cordata* Bl. of which the valid name is 'erosa' occurring in N.E. Asia. In China *C. erosa* Bl. is common in Manchuria and a little southward to Hopei, where, however, it is not common. *Carpinus erosa* Bl. is subglabrous in habit and the leaves are much larger than this species. *Carpinus erosa* Bl. and *C. chinensis* (Ledeb.) P'ei are very similar in general appearance. In both species specimens when arranged according to locality from north to south present a series of changes in pubescence on branchlets, petioles and leaves. But the difference between them is easily seen. *Carpinus erosa* Bl. has glabrous branchlets and petioles, with leaves subpilose on the under side; while *C. chinensis* has leaves always pubescent and densely pilose on veins beneath, and its branchlets and petioles have varying degrees of pubescence according to age.

Carpinus mollis, described by Rehder from a collection from Szechuan, seems to be an extreme form of *C. chinensis* and its characters are the same as those plants from Shansi, Anhwei and Chekiang. T. Tang's specimen from Shansi has subglabrous branchlets, sparsely pilose petioles and pubescent leaves with densely pilose lateral veins. The specimens from Anhwei and Chekiang have more hairy branchlets

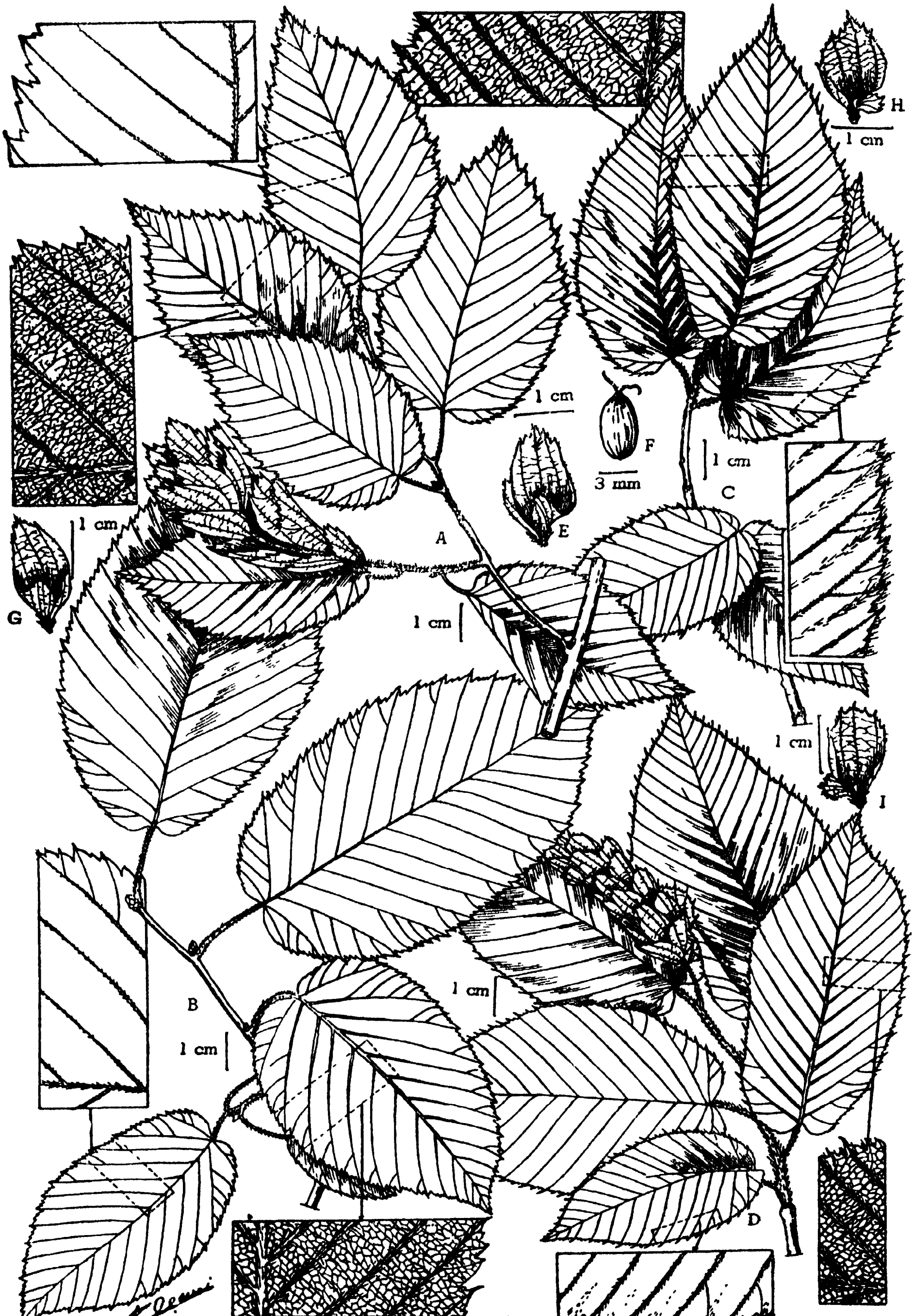

Fig. 2. *Carpinus chinensis* (Fr.) P'ei. A. Fruit branchlet drawn from the type of *Carpinus mollis* Rehd.; B. Branchlet drawn from Kansu plant; C. Branchlet drawn from Anhwei plant; D. Fruit branchlet drawn from Chekiang plant; E. Fruit bract of A.; F. Nut of A.; G. Fruit bract of B.; H. Fruit bract of C.; I. Fruit bract of D.

and petioles, but those collected late in the year have relatively short hairs on branchlets and petioles. The young branchlets and petioles have hairs very conspicuous to the naked eyes.

CARPINUS TURCZANINOWII Hance, Jour. Lin. Soc. Bot. 10: 203. 1869.

Carpinus Paxii Winkl., Engler Pflanzenr. 4 (16): 35, fig. 10, A-C. 1914.

Small trees up to 8 m. tall, bark grayish-brown, branchlets grayish-brown; leaves ovate, or in southern forms elliptic-ovate to oblong-lanceolate, doubly serrate, acute, rarely short-acuminate at apex, rounded to subcordate at base, subglabrous above, villous on veins and with tufts of hairs beneath, 3-6 cm. long, 1.5-3.5 cm. broad; veins about 11 pairs; petioles villous, 5-12 mm. long; spikes short, about 3 cm. long; bracts oblique-ovate, about 1 cm. long, glabrous within, pilose on veins without, with few teeth; nut small, 3 mm. long.

Shantung: Tsinan-fu, Lungtung, on rocky slopes, *C. Y. Chiao 3071*, Sept. 7, 1930.

Hopei: Tze-ping-tai, *Y. Yabe*, June 21, 1907. Without precise locality, *C. F. Li 10020*, 1929.

Shansi: Mien, Chiahsiu-hsien, alt. 1520 m. open slopes, *T. Tang 848*, May 27, 1929, "Small tree, 6 feet high, bark grayish-brown, lenticellate".

Kansu: Pailung-kiang, *C. K. Chow*, July-Oct. 1944. Hsiolung-shan, *C. H. Hé*, June-Aug. 1945.

Kiangsu: Haichow, Yuntai-shan, *T. P. Chang 895*, Oct. 20, 1932, "Shrub 5 feet high, bark brownish-lustrous".

Chekiang: S. Chekiang, *R. C. Ching 2584*, Sept. 4, 1924.

Distrib.: Also in Korea, Manchuria and western China.

The typical form is restricted to northern China, of which the leaves are ovate. On plant growing in southern China, the leaves are elongated to elliptic-ovate or narrowly oblong-lanceolate, but the fruiting bracts are all the same.

CARPINUS TSCHONOSKII Maxim, Mél. Biol. 11: 313. 1881.

Carpinus paohsingensis Hsia, Contr. Inst. Bot. Nat. Acad. Peiping, 2: 179, t. 13. 1931.

Trees up to 20 m. tall; branchlets chestnut-brown, densely villous when young; leaves elliptic-ovate to rhomboid-ovate, doubly serrate, pilose on both surfaces, densely on veins, tapering at apex, cuneate to broad-cuneate at base, 4-8 cm. long, 2-3 cm. broad; veins about 14 pairs; petioles villous, 1-1.5 cm. long; spikes up to 4 cm. long, with slender and villous peduncle; bracts of fruit oblique-ovate, sparsely villous inside, densely villous on veins without; nut about 2.5 mm. in diameter.

Kansu: Pailung-kiang, *C. K. Chow*, July-Oct. 1944.

Distrib.: From Japan and Korea southward to coastal provinces and southwestward to Szechuan.

This species is very much similar to *Carpinus Turczaninowii* Hance, from which it is distinguished by its large and elliptic- to rhomboid-ovate leaves, with cuneate or broadly cuneate base.

OSTRYOPSIS Decaisne

Deciduous shrubs; buds acute, protected by many imbricate scales; leaves ovate, doubly serrate, plicate in buds; flowers opening with the leaves; staminate flowers

without perianth in pendulous oblong-cylindric catkins, naked in winter; each bract with 4-6 stamens; filaments bifid at apex; anthers pilose at apex; pistillate flowers, enclosed in a trifid involucre in very short spikes, each bract with two flowers; calyx adnate to the ovary; ovary with one ovule in each cell; style bifid; fruit a small nutlet enclosed in a tubular involucre, trifid at apex; cotyledons above ground, green.

2 species in China; one is commonly occurred in northwestern China.

OSTRYOPSIS DAVIDIANA Dcne., Bull. Soc. Bot. France, 2: 155. 1873.

Corylus Davidiana Baill., Hist. Pl. 6: 224, fig. 174. 1877.

Shrub up to 3 m. tall, with suckers at base; bark gray, smooth; branchlets glabrous, pubescent while young; leaves ovate to broad-ovate, acute to acuminate at apex, cordate at base, doubly serrate or lobulate, 3-6.5 cm. long, 2-4 cm. broad, slightly hairy on veins above, pubescent on veins and reddish glandular-dotted beneath; petiole 5 mm. long; fruit 6-12 in a dense cluster on a long slender stalk; involucre 1.2-7.8 cm. long, soon splitting on one side; nutlet ovoid, beaked, about 8 mm. long.

Chahar: Kalgan, *C. D. Reeves,* Aug. 1921.

Shansi: S. Shansi, alt. 1200 m. open slopes, *T. Tang 782,* May 18, 1929, "Shrub 3-4 feet high, bark gray, nearly smooth".

Kansu: Pailung-kiang, *C. K. Chow,* July-Oct. 1944.

Distrib.: Also reported in Honan, Shensi and Szechuan.

This species is common in northwestern China on dry open slopes.

CORYLUS Linnaeus

Deciduous shrubs, rarely trees; buds usually obtuse, or sometimes acute, protected by many imbricate scales; leaves generally ovate to rounded, usually doubly serrate, more or less pubescent, conduplicate in bud; flowers before leaves; staminate flowers without perianth, catkins cylindric, pendulous, naked in winter; each bract with 4-8 stamens, filaments bifid, anthers pilose at apex; pistillate inflorescence head-like, enclosed in a small scaly bud, with only the red styles protruding; ovaries with 1, rarely 2 ovules in each cell; style bifid from the base; fruit a subglobose or ovoid nut, with ligneous pericarp, included or surrounded by a large leafy variously toothed or dissected involucre, often tubular, in clusters at the end of the branchlets; cotyledons thick, fleshy, remaining inclosed in the nut.

About 15 species in North America, Europe and Temperate Asia; often cultivated for their edible nuts and some for ornaments. 2 species common in northwestern China.

1. Involucre spiny; leaves glabrous but pubescent on veins beneath, with acuminate teeth; buds acute ..... *C. tibetica.*
1.. Involucre not spiny; leaves usually pubescent, with scarcely acuminate teeth; winter buds obtuse ..... *C. Sieboldiana* var. *mandshurica.*

CORYLUS TIBETICA Batal., Act. Hort. Petrop. 13: 102. 1893.

Corylus ferox var. *thibetica* Fr., Jour. de Bot. 13: 200. 1899.

Trees up to 8 m. tall; branchlets chestnut-brown, glabrous, pubescent when young; leaves chartaceous, ovate to oblong, doubly serrate, glabrous or sparsely pilose above, pilose on veins beneath, shortly-acuminate at apex, rounded to cordate at base, 6-13 cm. long, 4-6.5 cm. broad; lateral nerves about 10 pairs; petiole about 2.5 cm. long, glandular-

villous; staminate catkins on short axillary branchlets, usually tomentose; bracts acuminate, ciliate; pistillate clusters, globose; involucre villous, with laciniate-multifid spines.

Kansu: Huang-chia-lu-shan, *C. K. Chow*, June-Oct. 1944.

Distrib.: Also in Hupeh, Szechuan, Sikang and Yunnan.

CORYLUS SIEBOLDIANA Blume var. mandshurica (Maxim. et Rupr.) Schneid., Sargent's Pl. Wilson, 2: 454. 1916.

Corylus mandshurica Maxim. et Rupr., Bull. Acad. Sci. St. Petersb. 15: 137. 1856.

Corylus rostrata var. *mandshurica* Regel, Bull. Acad. Sci. St. Petersb. 15: 221. 1857.

Corylus Sieboldiana Schneid. Ill. Handb. Laubholzk. 1: 150. 1904. quoad fig. 830.

A small tree up to 6 m. tall; branchlets glabrous, finely pubescent when young; leaves ovate-oblong to nearly orbicular, lobulate at upper portion, chartaceous, doubly serrate, abruptly truncate or acuminate at apex, cordate at base, sparsely pubescent above, pubescent beneath, 5-9 cm. long, 4-6.5 cm. broad; lateral veins about 6 pairs; petioles pilose, about 2.5 cm. long; female flowers clustered, with involucre connate, becoming a long tube, irregularly toothed at the mouth, slightly constricted above the fruit, densely covered with yellow stiff hairs; fruit puberulous.

Kirin: Without precise locality, *F. H. Chen 2523*, 1930.

Liaoning: Tsao-ho-kou, *Y. Yabe*, Aug. 1910 and Aug. 18, 1917.

Shantung: Tsinglung-shan, *M. M.* June 27, 1918.

Hopei: Miaofeng-shan, *Y. Yabe*, Aug. 22, 1908. Peihua-shan, *Y. Yabe*, June 27, 1905. Hsiaowutai-shan, T'e ling-tze, *Y. Yabe*, July 28, 1906. Without precise locality, *H. T. Tsai 50268*, 1930.

Shansi: Ja-siu, *C. T. Ren 6114*, Aug. 26, 1923. Wutai-shan, alt. 5600 feet, shady slopes, *T. Tang 1084*, July 14, 1929, "Shrubby tree, 7 feet high, bark gray, nearly smooth".

Kansu: Between Choni and Lanchow, alt. 2600 to 3000 m., *R. C. Ching 1023*, Sept. 10-21, 1923, "Shrub up to 15 feet high". Hinglung-shan, *C. K. Chow*, Aug. 1942. Pailung-kiang, *C. K. Chow 28*, June-Oct. 1944.

Szechuan: Without precise locality, *W. P. Fang 4168*, 1928.

Distrib.: Commonly grown in Japan, Korea and Manchuria, southward to North China and southwestern provinces.

THE WOOD STRUCTURE OF METASEQUOIA DISTICHA

C. H. YU

The wood structure of *Metasequoia glyptostroboides* Hu et Cheng which should be properly called *M. disticha* (Heer) Miki as pointed by Teng (7), has been studied by Liang et al (5) and Li (4); but their results do not quite agree. An investigation to confirm their results seems necessary.

The material for the present study was supplied by the Department of Forestry, National Central University. It was collected from Lichuan, Hupeh, and consists of a portion of a cross section of mature stem, including both heartwood and sapwood. Sections were prepared by the use of a sliding microtome and stained by Haidenhain's iron-alum haematoxylin; safranin was used as a counterstain. The work of Bailey and Faull (1) was constantly consulted during the progress of the study.

OBSERVATION AND DISCUSSIONS

GROWTH RINGS: very distinct; contrast between the summer- and spring-wood tracheids very marked as seen in the transverse section. Ratio of the width of summer- to spring-wood ranging from 1:1 in the narrowest ring to 1:15 in the widest ring, generally about 1:6-8 in the inner growth rings and 1:2-4 in the outer growth rings. Li states 1:3; this will fall in the range of the latter case only. The transition between the thin- and thick-walled tracheids in the wider rings is usually gradual, but rather abrupt in the narrower rings. The difference between the two types of tracheid is more marked in the outer rings as compared with that in the inner rings.

TRACHEIDS: The form of the tracheids, as seen in transverse sections, is usually rectangular in the summer-wood; square, asymmetrically pentagonal or hexagonal in the spring-wood; and oval or oblong in the transitional zone. The diameter (tangential) of the tracheids is narrower in the inner rings (generally about 45 μ) and wider in the outer rings (generally about 55 μ), the extremes being less than 30 μ to more than 75 μ. Trabeculae are usually present. Resinous tracheids are also found.

On radial section, pits of the tracheids are bordered, usually with somewhat irregularly thickened membranes and irregular or disk-like tori. These pits are generally orbicular, oblong or oval with circular or oval apertures in the spring-wood tracheids; oval, with lenticular or slit-like apertures in the summer-wood tracheids. Rodlike or eyebrowlike bars of Sanio are present. In the summer-wood tracheids, the pits on the radial walls are usually uniseriately arranged and few in number. In the spring-wood tracheids, the pits are always numerous and multiseriate near both ends, sparse and uniseriate at the middle portion of the tracheid. Pits in the outer rings are usually arranged in three opposite longitudinal rows in the first-formed tracheids, two rows in the next formed tracheids, and one row in the last formed spring-wood tracheids; in the inner rings, they are in two opposite rows in the first-formed, one row in the late-formed spring-wood tracheid. Liang states "radial pitting biseriate in the first-formed tracheids but mostly arranged in one row", and Li states "Bordered pits in 1-2 (frequently 1) rows on the radial walls". Neither of their statements describe fully the whole situation.

On tangential section, pitting occurs not only in the summer-wood tracheids but also in the spring-wood tracheids. Bars of Sanio are wanting. Pits in the summer-wood tracheids are numerous, small, circular or oval with lenticular or slit-like coalescent apertures, arranged in one to three irregular longitudinal rows (Three rows occur only rarely in the outer rings never in the inner rings.) Pits in the spring-wood tracheids are larger, sparse, oblong or oval with oval apertures, and arranged in a single row.

LONGITUDINAL PARENCHYMA: As seen in the transverse section, the parenchyma cells are rectangular in form, filled with orange-brown resinous contents. The quantity and distribution of the parenchyma in each ring are uncertain. It may be abundant, diffused or sometimes aggregated into more or less conspicuous tangential lines extending considerable distances in both spring- and summer-wood in some rings; or sparse and diffused in other rings. Liang states that the parenchyma is sparse, while Li says it is abundant and metatracheal. Both conditions are to be found. If both of these authors

have observed more extensively, there will be no such contradictory statements. According to the writer's observation, the parenchyma seems to be more abundantly developed in the inner than in the outer rings. On the end walls of the parenchyma cells, two or more bead-like thickenings frequently develop. Half-bordered pits with broad oval or lenticular apertures are found where the parenchyma cells come in contact with the tracheids.

RAYS: The rays vary from 1 to 35 cells in height, mostly less than 20 cells high; they are uniseriate, but sometimes partially biseriate. The partial biseriation may extend vertically for several cells in some instances, but ordinarily, it consists merely of two cells lying side by side near the middle portion of the ray. The ray cells are all parenchymatous, frequently or occasionally containing resinous deposits. As seen in radial sections, the ray cells are rectangular, or somewhat tapering with curved or diagonally oriented end walls. The marginal cells of the rays are usually higher than the central ones, and are provided with conspicuous wavy outer horizontal walls. The horizontal walls of ray cells are always thinner than the adjacent tracheal walls and moderately or sparsely pitted. The end walls are smooth and as thick as the horizontal walls. The indentures are rare and inconspicuous at the corner of the ray cells. Liang, however, states "horizontal wall thick, unpitted, indentures absent". This error may be caused by improper staining or insufficient observation.

Pits in the cross-field vary greatly in shape even in the same growth ring or in the same cross-field, and particularly in the spring-wood. They are predominantly taxodioid but sometimes cupressoid. Li states that the pits are simple. This is an inexcusable mistake, for no simple pit is to be found. Liang states that the cross-field pitting is typically taxodioid and he separates the genus *Metasequoia* from *Taxodium* on this basis. As a matter of fact, both genera are similar to each other so far as the type of cross-field pitting is concerned. The number of pits in each cross-field in the spring-wood is generally 2-4 in the middle cells, 3-5 in the marginal cells and arranged in one horizontal row, very rarely in two rows in the marginal or higher cells of the ray. In the summer-wood, the number of pits in each cross-field is mostly one, sometimes two arranged vertically.

TRAUMATIC RESIN CANALS: As illustrated by Liang, these canals occur, but there is no traumatic ray tracheid in the material at hand.

Quantitative measurements of the structural elements have been made by Liang et al. With the scanty material at the writer's disposal, such statistical investigation is therefore not attempted.

SUMMARY AND CONCLUSIONS

From the above observation, the structure of the wood of *M. disticha* may be briefly described as follows:

Tracheids up to 75 μ in diameter, generally about 45-55 μ; bordered pits on radial walls of spring-wood tracheids numerous and multiseriate near both ends, sparse and uniseriate at the middle portion, arranged in 1-2, rarely 3 opposite, longitudinal rows. Tangential pitting numerous, small, and arranged in 1-2 rarely 3 irregular longitudinal rows in the summer-wood tracheids; sparse, larger, and arranged in 1 row in spring-

wood tracheids. *Parenchyma* present, sparse to abundant, diffused to metatracheal; end walls nodular. *Rays* usually less than 20 cells high and uniseriate, consisting entirely of ray parenchyma; horizontal walls thin, moderately or sparsely pitted; indentures rare and inconspicuous; pits in the cross-field 1-5 (generally 2-4), predominantly taxodioid, sometimes cupressoid, arranged in one horizontal row in the spring-wood.

According to the work of Jeffrey (3), the presence of abundant parenchyma, bars of Sanio, and traumatic resin canals, and the absence of spiral thickenings, normal resin canals, and ray tracheids in the wood of *Metasequoia* show that this genus is more advanced than all the genera of Taxaceae, Podocarpaceae, Araucariaceae and Pinaceae; but is related to those of Taxodiaceae and Cupressaceae. When compared with the anatomical data of the different genera of coniferous wood made by Phillips (6), the genus *Metasequoia* possesses only one character, i.e., the thin horizontal wall of ray cell, which favors its placement in the Cupressaceae. On the other hand, there are three characters which decide its inclusion in the Taxodiaceae. These characters are: (1) Predominance of taxodioid type of cross-field pitting, (2) tracheids up to 75 μ in diameter and the arrangement of pits on radial walls of spring-wood tracheids in 1-3 opposite longitudinal rows, and (3) numerous tangential pitting in summer-wood and also in spring-wood tracheids.

From the standpoint of wood anatomy, there are no important characters of *Metasequoia* which demand the erection of a new family as Hu et Cheng (2) have proposed. The writer agrees with Teng (7) in that the genus "might well be regarded as the most advanced genus in the family Taxodiaceae"; and "serves as a link connecting the two families", Taxodiaceae and Cupressaceae. The genus *Metasequoia* is easily separated from the other genera of Taxodiaceae, except *Sciadopitys*, by its thin horizontal walls of ray cell, and from *Sciadopitys* by its moderately or sparsely pitted horizontal walls of ray cells.

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THE EFFECT OF INDOLE-3-ACETIC ACID ON ROOT FORMATION AND BUD DEVELOPMENT

T. L. Loo and Y. W. Tang

Recent researches dealing with the physiological role of indole-3-acetic acid lead to the conclusion that there are two specific effects of this acid on plant growth, namely; root production and inhibition of bud growth. Laibach (11), Fischnich (4), and Laibach and Fischnich (12) induced root production by applying indole-3-acetic acid in lanolin to the intact stems of *Coleus, Vicia Faba,* and *Solanum.* Hitchcock (7, 8) and Zimmerman and Wilcoxon (29) secured root production on the intact plant by local application of lanolin paste containing this acid. Cooper (1) succeeded in using indole-3-acetic acid for root cuttings of lemon. Later Hitchcock and Zimmerman (9) and Cooper (2) observed the same effect of indole-3-acetic acid in the root formation of cuttings of *Ilex, Taxus, Hibiscus, Citrus, Chrysanthemum* etc. when the base of cuttings was treated with this chemical. Thus, the fact that indole-3-acetic acid stimulates root formation has been firmly established. As to the inhibitive effect of indole-3-acetic acid on bud growth, there are also ample evidences. Thimann and Skoog (17), for example, found that the application of the paste containing this acid to the decapitated etiolated seedlings of *Pisum* and *Vicia Faba* inhibited development of lateral bud. That application of pure heteroauxin on the cut petiole inhibited the growth of next bud was observed by Goodwin (6). Using *Aster* as test plant Delisle (3) reported that pure auxin inhibited the bud development. Went (20) in an experiment with etiolated pea shoot concluded that the growth of lateral bud was inhibited by the application of indole-3-acetic acid. Skoog (15) working with the solution culture method obtained results showing that the growth of excised buds of *Pisum* was inhibited by adding indole-3-acetic acid to the culture solution. Although the mechanism of this inhibitive action is still unknown there seems to exist an unanimous opinion regarding this inhibitive effect of auxin on bud growth.

In the experiments with leafless cuttings of willow tree which will be described in the following lines, the writers found, however, that indole-3-acetic acid inhibited the formation of visible buds rather than the development of bud and that it hastened the date of appearance of adventitious roots and stimulated their initial growth.

MATERIAL AND METHOD

The stem cuttings of willow tree were used as test material in this experiment. Twigs of about 30 cm. long and 1-2 cm. in diameter were cut from the plants. The detached twigs were cut in the middle so that the resulting two halves are almost of equal length. These two halves were weighed and only pairs of equal weight were used in the experiment. One of the pairs was used for the treatment and another for the control, care being taken that the morphological polarity of the cuttings should not be disturbed. Synthetic indole-3-acetic acid in lanolin was used in the treatment with pure lanolin as control. The concentration of the lanolin mixture was 1%, i.e., 10 mg. of indole-3-acetic acid per gram of pure lanolin. About 20 mg. of this paste were smeared on the apical end of the cut surface and left on throughout the experiment. Both control and treated cuttings used were leafless.

EXPERIMENTAL RESULTS

THE EFFECT OF INDOLE-3-ACETIC ACID ON THE DATE OF ROOTING AND BUDDING. Treated and control cuttings were simultaneously immersed in large test tubes containing 80 cc. of redistilled water which was renewed every week. The numbers of roots and visible buds were recorded every day. These results are shown in tables 1 and 2. The root initiation on treated cuttings was three days earlier than that of control. On the third day after treatment seven out of eight treated cuttings produced visible roots while control cuttings were all leafless. On the other hand, the visible buds on the treated cuttings appeared two days later as compared with the control. The development of visible buds of both treated and control cuttings was similar. As a whole, indole-3-acetic acid stimulated root production, but inhibited visible bud formation. (Table 3).

TABLE 1. DAILY RECORD OF THE ROOT NUMBER OF CUTTINGS TREATED WITH INDOLE-3-ACETIC ACID-LANOLIN MIXTURE & WITH PURE LANOLIN USED AS CONTROL

Date	Number of roots of each cutting																Sum of the root number of 8 cuttings	
	Treated								Control									
	a	b	c	d	e	f	g	h	a	b	c	d	e	f	g	h	Treated	Control
May 24	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3	0
„ 25	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	4	0
„ 26	1	1	2	2	1	1	0	4	0	0	0	0	0	0	0	0	12	0
„ 27	2	2	8	4	1	1	3	4	0	0	0	0	0	0	0	0	25	0
„ 28	6	2	2	0	0	0	2	4	0	1	2	0	0	0	1	1	16	5
„ 29	0	1	3	5	1	2	5	3	0	0	2	0	0	0	0	1	20	3
„ 30	1	2	1	2	2	3	1	1	3	1	2	0	0	2	0	0	13	7
„ 31	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	3	0

TABLE 2. DAILY RECORD OF THE VISIBLE BUD NUMBER OF CUTTINGS TREATED WITH INDOLE-3-ACETIC ACID-LANOLIN MIXTURE & WITH PURE LANOLIN USED AS CONTROL

Date	Number of visible buds of each cutting																Sum of visible number of 8 cuttings	
	Treated								Control									
	a	b	c	d	e	f	g	h	a	b	c	d	e	f	g	h	Treated	Control
May 24	0	0	0	0	0	0	0	0	0	2	2	3	2	1	5	5	0	20
„ 25	0	0	0	0	0	0	0	0	0	2	3	5	4	6	1	1	0	22
„ 26	1	0	0	1	2	0	0	0	0	1	2	5	2	1	2	0	4	13
„ 27	0	3	0	1	0	0	0	0	3	4	1	0	0	3	1	1	4	13
„ 28	0	0	0	1	0	0	0	0	2	2	1	1	0	1	0	1	1	8
„ 29	0	0	0	0	0	0	0	0	2	0	0	1	4	0	0	0	0	7
„ 30	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
„ 31	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0

TABLE 3. TOTAL NUMBER OF VISIBLE BUDS AND ROOTS SUMMARIZED FROM TABLE 1 AND 2.

Cutting surface treated with	No. of roots	No. of visible buds
Pure lanolin	15	84
Indole-3-acetic acid-lanilin mixture	96	10

TABLE 4. REGENERATION OF ROOT & SHOOT OF CUTTINGS TREATED WITH PURE LANOLIN AND 1% INDOLE-3-ACETIC ACID. DATE: JUNE 17—JUNE 29.

Cutting surface treated with	No. of bud	No. of root	Total length of root (mm.)	Dry weight (gm.) Root	shoot
Pure lanolin	87	15	453	0.0215	0.7796
Indole-3-acetic acid-lanolin mixture	15	65	1747	0.1004	0.0685

THE EFFECT OF INDOLE-3-ACETIC ACID ON THE PRODUCTION OF ROOT AND BUD IN WILLOW CUTTINGS. After treatment the cuttings were set in propagating frame containing equal parts of sand and garden soil. Adequate amount of water was applied every day. The length of cuttings in soil was 8 cm. On the 9th day after treatment, all the cuttings of the control lot initiated visible buds whereas no visible bud appeared on treated cuttings. The number of buds and roots, total length of the root, and the dry weight of the root and the bud were determined at the end of the experiment. The results are shown in table 4. It is clear that the effect of indole-3-acetic acid on root and bud formation was just the same as that in the foregoing experiment. As regard to the the production of dry weight substances, the presence of indole-3-acetic acid caused acceleration in the root but induced a depression in the shoot.

THE EFFECT OF TREATMENT AFTER APPEARANCE OF VISIBLE BUDS. As shown above though indole-3-acetic acid inhibited bud formation, yet the development of the visible bud was as good as that of the control. In order to ascertain the effect of indole-3-acetic acid on bud formation and development of visible buds the following experiment was carried out. The leafless cuttings were placed in a moist bell jar till the reappearance of visible buds. The indole-3-acetic acid in lanolin paste was applied to the cut surfaces with pure lanolin as control and then set in propagating frame. The number of roots and of buds, the length of root, and the dry weight are shown in table 5. The number, total length and the dry weight of root of treated cuttings were much greater than those of the control. Though the number of buds of control cuttings was slightly greater than that of the treated cuttings, buds of both control and treated cuttings developed similarly, however. No significant difference of dry weight between the control and the treated lot was observed and the average increase in dry weight per bud was at least equal to, if not greater than, that of the control.

TABLE 5. REGENERATION OF ROOT AND DEVELOPMENT OF REAPPEARED VISIBLE BUD OF CUTTINGS TREATED WITH PURE LANOLIN AND 1% OF INDOLE-3-ACETIC ACID-LANOLIN MIXTURE. DATE: JULY 19—AUG. 10.

Cutting surface treated with	No. of bud	No. of roots	Total length of root (mm.)	Dry weight (gm.) Root	Shoot	Mean dry weight of developed bud
Pure lanolin	80	153	4956	0.0991	2.4865	0.0312
Indole-3-acetic acid-lanolin mixture	67	236	7920	0.2002	2.3581	0.0351

DISCUSSION

The above results indicate that indole-3-acetic acid promotes root production. Working with pea cuttings, Went (21) suggested that indole-3-acetic acid did play a

dual rule in root formation by first mobilizing rhizocaline and then reacting with it. That the treated cuttings root earlier than that of control may be due to the earlier activation of the rhizocaline. The results of experiments on lemon cuttings performed by Cooper (2) suggest that an important function of indole-3-acetic acid in root formation is in the control of transport of rhizocaline.

As to the effect of indole-3-acetic acid on the bud growth, the writer's findings show that it inhibits bud formation of leafless cuttings. Different suggestions regarding the mechanism of inhibition have been given by many investigators: (1) Auxin is considered to act directly on the inhibition organ (concentration effect, Thimann 18); (2) Auxin causes an accumulation of caulocaline (bud growth factor) at the point of application (Went 19, 21) or affects the availability or the translocation of nutrients (Laibach 10, van Overbeek 14); (3) Under the influence of indole-3-acetic acid an inhibition substance is formed (Snow 16). It seems to the writers that Went's interpretation is more plausible than others. As the above results show, there is callus formation at the point of application of this acid. The exhaustion of available food necessary for bud formation may have something to do with the inhibitive effect of auxin.

From table 5 it is evident that indole-3-acetic acid does not effect the development of pre-existing buds, though this acid does inhibit the bud formation in leafless cuttings. This phenomenon may be explained either by assuming that bud inhibition and bud development are two different phases of bud growth, indole-3-acetic acid inhibiting the former but playing no role in the latter, or that the application of indole-3-acetic acid might cause a downward movement of the factor (or factor) which is necessary for the formation of bud. Whenever the bud initiates the growth center is located and the growth factor (or factors) would move to it as suggested by Goebel (5) and Loeb (13). Besides, the visible bud itself can synthesize food for its development. Therefore, the application of indole-3-acetic acid, does not effect the subsequent growth of pre-existing buds in cuttings.

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THE SUBAERIAL ALGAE FROM THE PARACEL ISLANDS IN THE SOUTH CHINA SEA

SHANG-HAO LEY

In the late spring of the year 1947, the writer paid a visit to the Paracel Islands in the South China Sea for collecting the freshwater and marine algae. The freshwater forms collected are confined to all the species distributed on the Woody Island; and, as no any kind of freshwater bodies appears on this island, they are wholy subaerial in habit. In this report, these subaerial forms are dealt with. As we know that the algal flora of these islands is entirely unknown previously, some species listed in this report may be of interest as far as their geographical distribution is concerned.

Woody Island is situated at the northeastern part of the Paracel Islands, and located at 16° 50' N. L. and 112° 20' E. L. It is a small coral island extending from NW to SE, about 5900 feet long, 3600 feet broad, and standing at an altitude of 2—15 feet above the sea level. No rocks are present there. Its surface is covered nearly all over by a layer of guano, the excrement of sea fowls, with a thickness of several inches to about two feet. Under this layer, the substratum is built of corals mixed with the fragments of shells and calcareous algae.

According to previous records on the climate of this island (4), the temperature is always above 70° F all the year round. The mean temperature of the coldest month, January, is 75. 45° F; that of the warmest month, May, is 89.99° F; and that of a year is about 85° F. In daytime the temperature varies so greatly from time to time. In the afternoon it is usually 15° F higher than that in the forenoon. In a year, there are about 100.5 raining days.

The forest occupies most part of the Island. It is composed of a dense growth of *Pisonia alba* Spanoghe. Occasionally, a few scattered *Gnettarda speciosa* L. may occur among them, and the shrubs, *Morinda citrifolia* L. and *Tournefortia argenten* L., may be found along their margin.

The subaerial algae found on this Island are either epiphytic on the bark of *Pisonia alba* (*Ley 665, 666, 667, 668, 669, 670, 671, 672, 673, 675, 677, 678, 679, 680, 681,* and *682*) or growing on the blocks of guano (*Ley 674, 676A, 676B,* and *683*). The total number of the species, varieties, and forms are thirty-two, among them, two varieties and one form are described as new to science. Type specimens of these new forms are kept in the Herbarium of the Institute of Botany, Academia Sinica.

MYXOPHYCEAE

CHROOCOCCACEAE

Microcystis Kuetz., 1833

Microcystis amethystina (Filarsz.) Forti, in De Toni's Syll. Alg. 5. Myxophy. 89. 1907.

Forma. (Fig. 1. *d*)

Colonies usually spherical, sometimes becoming irregular with age, up to 68 μ in diameter; tegument thick, rigid, homogeneous, and orange to wine red, or sometimes dull purplish red; cells 1.5—3 μ in diameter, spherical or ellipsoid, often densely crowded; cell contents bluish green, with pseudo-vacuoles.

Common in *Ley 667, 669, 670* and *671*; mostly growing among the plant mass of *Scytonema* or *Lygnbya.*

The Chinese plant differs from the typical form in its beautiful orange to wine red colour of the rigid tegument, smaller cells, and cell contents with pseudovacuoles. Otherwise they are similar to each others. Printz (3), in 1921, described a variety, *M. amethystina* var. *vinea,* from South Africa. It differs from the typical form in its wine-red colour and smaller colonies. Because the difference in the coloration of tegument may be induced by ecological factors, this variety together with the present form should be referred to the typical form.

As the tegument of *Microcystis amethystina* var. *vinea* Printz and *M. fusco-lutea* (Hansg.) Forti shows a characteristic colour, Geitler (2, p. 141) suggested that they should be referred to the genus *Chlorogloea.* But their cell arrangement is dissimilar to that of *Chlorogloea.* It seems better to refer these species also to the genus *Microcystis.*

Gloeocapsa Kuetz., 1843

Gloeocapsa magma (Breb.). Kuetz., Tab. Phyc. 1: 17, 1845. (Fig. 1, *f, g.*)

Colonies solitary or somewhat aggregated, spherical, up to 26 μ in diameter, consisting of 4—32 cells; colonial tegument very rigid, not lamellose, reddish, sometimes orange colour; cells 4—5 μ in diameter; cell contents finely granulated, pale blue green.

Very common in *Ley 669.*

As described above, the Chinese plant is dissimilar to the typical form in having firm tegument, and families usually consisted of a large number of cells. In 1942, Daily (1) found these same features on the American specimens.

GLOEOTHECE Naeg., 1849

GLOEOTHECE GOEPPERTIANA (Hilse) Forti, in De Toni's Syll. Alg. 5: 62. 1907.

Scattered among the colonies of *Microcystis amethystina* in *Ley 667.*

GLOEOTHECE RUPESTRIS (Lyngbye) Born. var. MINOR Jao, Sinensia 10: 177, pl. 1, fig. 1, 1939. (Fig. 1, *e.*)

Forma tegumentis tenuioribus, homogeneis.

This plant forms the rigid, gelatinous masses of a yellowish brown colour. Its cells are 2.6—4 μ in diameter and up to 6.9 μ long.

Scattered among other algae in *Ley 674.*

DACTYLOCOCCOPSIS Hansg., 1888

DACTYLOCOCCOPSIS RUPESTRIS Hansg. f. SIGMOIDES, f. nov. (Fig. 1, *k.*)

F. strato amorpho; tegumento gelatinoso, confluenti, hyalino; callulis ellipsoideis, sigmoideis vel fusiformibus, 1—1.5 μ latis, 5—6 μ longis, contentu aeruginoso.

Fairy scattered among *Plectonema* in *Ley 674.*

The systematic position of this form is uncertain. According to previous published descriptions of this species, the colonies are enveloped only by a small amount of gelatinous matrix. In the Chinese plant, the gelatinous tegument, though confluent, is easily recognized, and the cells in each colony are always of a great number.

PLEUROCAPSACEAE

CHROOCOCCOPSIS Geitler, 1925

CHROOCOCCOPSIS GIGANTEA Geitler, Arch. f. Protk. 51: 342, fig. K. 1925.

Rather common in *Ley 670.*

This spscies is characterized by its less obvious filamentous tendency, stratified sheath, and reproducing by means of small endospores formed in a large number in each cell.

MYXOSARCINA Printz, 1921

MYXOSARCINA sp. (Fig. 1, *h-j*).

Colonis regularly cubically rotundate, 22—43 μ in diameter, tegument hyaline; cells mostly cubical and arranged more regularly in rows in the younger colonies, but becoming less regular in both shape and arrangement in the older ones, 5—8 μ diameter; individual sheaths invisible; propagation by endospores which are usually formed simultaneously by the divisions of the cell contents of the ordinary vegetative cells of a colony; cell contents pale blue green.

Scattered among *Gloeocapsa magma* in *Ley 669* and *683.*

Judging from the characteristics given above, the Chinese alga is merely a species of *Myxosarcina,* but it is very hard to say whether or not the alga should be referred to one of the known species. Up to date, only four freshwater species of this genus are known, viz., *M. concinna* Printz, *M. chroocoocoides* Geitler, *M. spectabilis* Geitler and *M. amethystina* Copeland. The Chinese plant differs from the first in having comparatively irregularly arranged and a little larger cells; from the second two in having rather regularly arranged and a little smaller cells; from the last one in colour and in the lack of prominent granule in its cell contents; and from them collectively in having indistinct

individual sheaths and blue green cell contents. According to this comparison, the Chinese plant has no distinct characters to separate itself from the known species. On the other hand, as its characteristics are equally closely allied to those of all the known species of the genus, it may be placed under any one of them as a form.

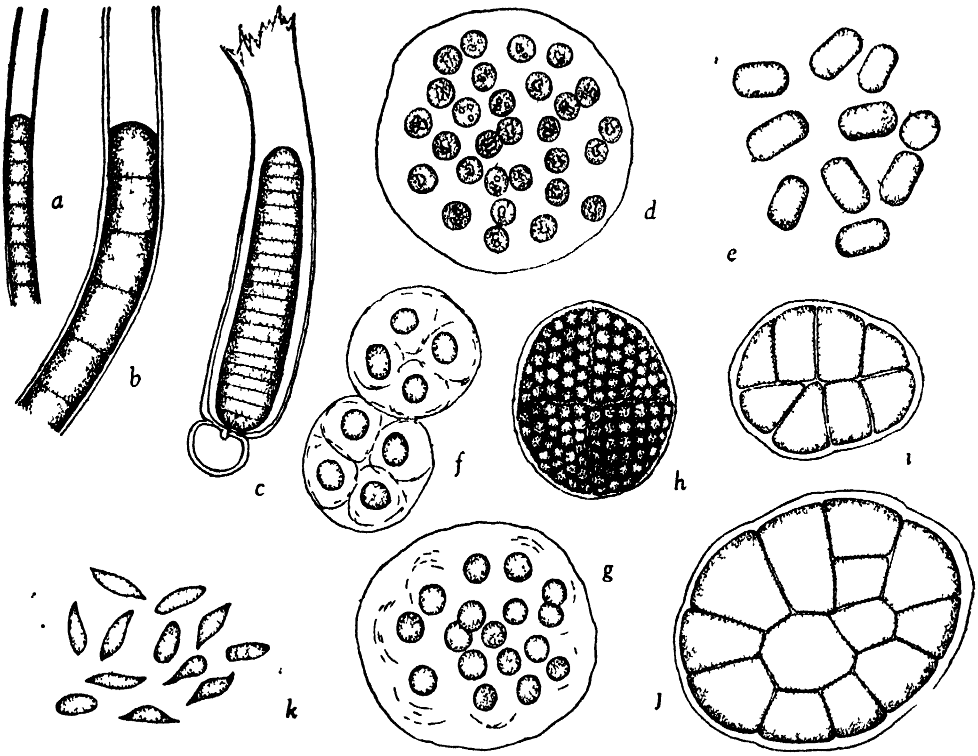

Fig 1 *a, Lyngbya Margaretheana* Schmid var *paracelensis* Ley, var nov *b, Lyngbya ceylonica* Wille var *hyalinus* Ley, var nov, *c Calothrix* sp *d Microcystis amethystina* (Filarsz) Forti, forma, *e Gloeothece rupestris* (Lyngbe) Born var *minor* Jao, forma, *f* and *g Gloeocapsa magma* (Breb) Kuetz, *h—j Myxosarcina* sp *k Dactylococcopsis rupestris* Hansg, f *sigmoides* Ley, f nov Figure *a* × 1850 figures *b c and* × 750 figures *e f, g,* and *k* × 1500 figures *h* and *i* × 1125 figure *j* × 1355

OSCILLATORIACEAE

Oscillatoria Vauch., 1803

Oscillatoria homogenea Frémy, Myx. d'Afr Equat Franc. 215, fig 184 1930
Scattered in *Ley 680.*

The Chinese plant differs slightly from the typical form of this species in some of their cells with pseudovacuoles. This may be due to its terrestrial habitats Otherwise, it is typical

Phormidium Kuetz., 1843

Phormidium angustissimum W. et G S. West, Jour. Bot. 35· 298. 1897.
Occasionally found among other filamentous algae in *Ley 674.*

PHORMIDIUM RUBRITERRICOLA Gardner, Mem. New York Bot. Gard. 7: 43, pl. 9, fig. 86. 1927.

Filaments 2.5—3 μ in diameter, sheaths very thin; end cells rounded, conical or even pointed.

Scattered among the plant masses of *Plectonema phormidioides* in *Ley 665.*

This species differs slightly from the typical form of this species in its inconspicuous cross walls. Otherwise it is typical.

PHORMIDIUM SCYTONEMICOLA Gardner, Mem. New York Bot. Gard. 7: 42. 1927.

Filaments free or twisted on the filaments of *Plectonema*; sheath very thin, hyaline, usually more conspicuous at the end of the filaments; cells 2.6—3 μ in diameter, 4—5 μ long.

Scattered among other algae. Although it is not so abundant, it is frequently met in several samples, *Ley 665, 672, 673, 677,* and *678.*

PHORMIDIUM TENUE (Menegh.) Gom., Monogr. Oscill. 169, pl. 4, fig. 23—25. 1892.

Filaments 3 μ in diameter, gradually tapering at the apex; sheath very thin, hyaline; cells up to 5 μ long.

Scattered in *Ley 667.*

The Chinese plant differs from the typical form of this species in the trichomes not constricted at the joint. Otherwise, it agrees with the typical form in all respects.

LYNGBYA Ag., 1824

LYNGBYA ALLORGEI Frémy, Myx. d'Afr. Equat. Franc. 189, fig. 156. 1930.

Filaments 5—5.2 μ in diameter; cells 3—5 μ in diameter, 5—5.5 μ long.

Very common in *Ley 668, 671, 678, 680* and *682.*

In some specimens, the apical cell is usually cylindrical in shape.

LYNGBYA CEYLONICA Wille., in Rechinger, Denkschr. math.- nat. Al. Akad. Wiss. Wien 91: 161, pl. 3, fig. 27—29. 1914.

Filaments 14 μ in diameter; trichoma 10.4 μ in diameter, 10—15.5 μ long.

Growing on mosses on the bark of the basal part of *Pisonia alba* in *Ley 666.*

This species is scattered on the leaves of *Calymperes* sp. It is very easily recognized by its purple cell contents. The cells are usually quadrate, but sometimes may be either longer or shorter than broad. In the well developed individuals, the cell contents are deep violet in colour and more or less inconspicuously granular, and the cross wall are straight. In the abnormal ones, which may be affected by drought, the cell contents become light violet in colour and distinctly granular, and the cross walls become convex or concave.

This species has previously been reported only from Ceylon, India, and French Equatic Africa.

LYNGBYA CEYLONICA Willie var. HYALINIA, var. nov. (Fig. 1, *b*)

Var. vaginis hyalinis; ceterum ut in forma speciei typica.

Rare in *Ley 668.*

The full data of this variety are: "Plant mass scattered among other algae, filaments 10—17.5 μ in diameter, straight or sometimes curved; sheath colourless, becoming thick

with age; trichomes 9—12 μ in diameter, not constricted at the joint; apex of trichome not tapering, not capitate, apical cell rounded; cells quadrate slightly longer than broad, 9—11 (-13) μ long; transverse wall not granulated; cell contents pale blue green."

In size, this species is near to *Lyngbya stagnina* Kuetz. and *L. Martensiana* Menegh., but differs from them in having much longer cells and cross walls not granulated.

LYNGBYA MARGARETHEANA Schmid var. PARACELENSIS, var. nov. (Fig. 1, *a*)

Var. cellulis quadratis, longitudine raro ad 4 μ; dissepimentis non granulatis; cellula apicali cylindrica; ceterum ut in forma speciei typica.

Rather rare in *Ley 671.*

This variety differs from the typical form chiefly in (1) cross walls not granulate, (2) cells usually quadrate and occasionally up to 4 μ long, and (3) cylindrical apical cell. Otherwise, they agree with each other. In size, this variety should also be compared with *Lyngbya nana* Tilden, which forms the calcareous crusts and has the cells shorter than broad.

LYNGBYA PUTLALIS Mont. var. MINOR Geitler, Arch. f. Hydrobiol. Suppl. 12: 633. 1933.

Filaments 7—8 μ in diameter; cells 4—6 μ in diameter, 3—7 μ long.

Common in *Ley 667* and *671.*

RIVULARIACEAE

CALOTHRIX Ag., 1824

CALOTHRIX sp. (Fig. 1, *c*)

Filaments scattered or dense crowded, usually decumbent at base, 10.4—15 μ in diameter, up to 0.2 mm in length, not thickened at the base; sheaths thin, uniform or roughened, transparent or yellowish; trichomes 6.5—9 μ in diameter, moderately tapering from base to apex, not ending in a hair (?), not constricted at the joints; cells $\frac{1}{4}$ to $\frac{1}{8}$ times shorter than broad; heterocysts basal, hemispherical, single, 10.4 μ in diameter; homogones many within the sheath; cell contents blue green.

Scattered in *Ley 682.*

The present material consists only of older plants. The apex of the filaments examined are all broken down. The writer is not sure that the apex of the trichomes of this alga is not ending in a hair. Probably this alga might be referred to *C. parietina* (Naeg.) Thur.

SCYTONEMATACEAE

PLECTONEMA Thur., 1875

PLECTONEMA PHORMIDIOIDES Hansg., Oest. Bot. Zeitschr. 121. 1887.

Plant mass blue green; filaments 7—10 μ in diameter; sheath thin, firm, hyaline when young, becoming yellowish brown in older stages; cells 6.5—7 μ in diameter, 6—7 μ long; cell contents granular.

Growing on guano, very common in *Ley 676.*

In the typical form of this species, the cells are $\frac{1}{2}$ to $\frac{1}{3}$ times shorter than broad. In the Chinese plant, the cells are usually quadrate or a little shorter than broad.

PLECTONEMA RADIOSUM (Schiederm) Gom., Monogr. Oscill. 100, pl. 1, fig. 2—4. 1892.

Filaments 10—15.6 μ in diameter, sheaths hyaline when young, becoming yellowish

with age; trichomes constricted at the cross walls, occasionally becoming torulose in older stages; cells 7.8—10.4 μ in diameter, 3.5—13.5 μ long; cell contents granular.

Common in *Ley 665* and *666.*

Tolypothrix Kuetz., 1843

Tolypothrix byssoides (Hassall) Kirchner, Krypt. -Fl. Schles. 231. 1878.

Filaments 13 μ in diameter; trihomes slightly constricted at the cross walls, cells 10.5 μ in diameter, 3—5 μ long; cell contents granular.

Scattered among other algae in *Ley 671.*

The Chinese plant differs from the typical form of this species in having cells not merely barrel-shaped.

Tolypothrix granulata (Gardner) Geitler, in Rabenhorst's Krypt. -Fl. 14, Cyan. 727, fig. 446 b. 1932.

Filaments 17—18 μ in diameter; sheaths rather thick; trichomes slightly constricted at the cross walls; cells 13—14 μ in diameter, 3—5 μ long; heterocysts 12 μ in diameter, 3.5 μ long.

Rare in *Ley 675.*

The local form has thicker sheaths and slightly wider trichomes, which are dissimilar to those of the typical form.

Scytonema Ag., 1824

Scytonema Austinii Wood, Contr. Hist. Freshw. Alg. N. Amer. 58, 1874; Drouet, Bot. Gaz. 95: 700, fig. 10. 1934.

Filaments 13—15 μ in diameter, rarely branched; sheath firm, yellowish brown to deep brown, surface rough; trichomes constricted at the cross walls, 8—10.5 μ in diameter, 5.2—9 μ long; heterocysts cylindrical.

Growing with *Lyngbya Allorgei* and *Phycolimum monile,* common in *Ley 680.*

Scytonema Hansgirgi Schmidle, Allg. Bot. Zeitschr. 78. 1900.

Filaments 14.5—15 μ in diameter; cells 13 μ in diameter, 2—3 or rarely 5 μ long; heterocysts 12 μ in diameter, 5 μ long.

Common in *Ley 671.*

This species has previously been recorded by Schmidle only from East India. It is very easily recognized by the length of its cell being proportionally short.

Scytonema javanicum Born., in Born. et Thur., Notes Alg. 2: 148. 1880.

Filaments 7—10.4 μ in diameter; cells 9 μ in diameter, 3—5 μ long.

Very common in *Ley 671* and *672.*

The local form is smaller than the typical one.

Scytonema myochrous (Dillw.) Ag., Disp. Alg. Suec. 38. 1812.

Filaments 15—20.6 μ in diameter, sheath very thick, stratified; trichomes torulose, 7 μ in diameter; cells shorter than broad.

Rare in *Ley 669.*

Scytonema ocellatum Lyngb., Hydroph. Danica 97, pl. 28 A. 1819.

Rather common in *Ley 676.*

CHLOROPHYCEAE

CHLOROCOCCACEAE

CHLOROCOCCUM Fries, 1820

CHLOROCOCCUM HUMICOLUM (Naeg.) Rabenh., Fl. Eur. Alg. 3: 58. 1868; Bristol, Jour. Linn. Soc. Bot. 44: 473, pl. 17 & 18. 1919.

In most of the samples.

This species is one of the commonest aerophilous algae distributed on this island, although it is scattered among other algae. The cells vary from 5 to more than 20 μ in diameter. The cell wall usually thickens with age.

TRENTEPOHLIACEAE

TRENTEPOHLIA Martius, 1817

TRENTEPOHLIA UMBRINA (Kuetz.) Born., in Wille, Jahrb. f. Wis. Bot. 18. 426. 1887.

Scattered in *Ley 671 A*.

This species is occasionally found among other algae. Young plants with cylindrical cells are rather rare. The older plants, in which the cells are usually becoming round and with a thickened wall, are rather common.

PHYSOLINUM Printz, 1921

PHYSOLINUM MONILE (De Wildem.) Printz, K. Norske Viden. Sel. Skrift. 1920: 23, pl. 13, fig. 306—312. 1921.

Common in *Ley 668, 669, 670, 679, 680*. Especially abundant in *679*.

This interesting species is one of the commonest algae distributed on this island. It is usually associated with other Myxophyceae, or forms a dense and macroscopically visible mass. The second condition is dissimilar to that observed by Printz from his South African specimens. As to the structure of its vegetative filaments, it agrees in all respects with the original description given by former authors. Unfortunately, there are no reproductive cells, aplanospores, found by the writer, although a considerable amount of specimens has been examined. Probably, the reproductive cells of this alga might appear only under certain climatic conditions or in certain season. According to Printz's record (3), its aplanospores are developed in the period from October to November in South Africa.

This species has also been found by Dr. C. C. Jao and the writer in Szechwan.

In conclusion, I wish to express my thanks to Dr. C. C. Jao for his valuable help throughout this work.

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AN INQUIRY INTO THE NATURE OF SPELTOID AND COMPACTOID TYPES OF WHEAT AS A FUNCTION OF GENIC DOSAGE

H. W. Li, C. A. Hsia, and C. L. Lee

Since the discovery of speltoid wheat in 1904 by Nilsson Ehle in Sweden, the problem of the origin of speltoid as well as of compactoid has attracted the attention of geneticists and cyto-geneticists the world over, and a voluminous literature has been published. In 1946, Huskins has made an excellent summary of this puzzling problem (Huskins 4). His conclusions were that:

1. Series α het speltoids segregated as if they differed from the normal by a single unit factor, so it had been argued that they arose by gene mutation. Those giving ratios closely approaching 1:2:1 had no chromosome-deficiency large enough to be detectable at meiotic metaphase. Some het speltoid which were intermediate, and had by Nilsson Ehle and others, been classed as series α had a visible deficiency.

2. Series β het speltoid involved the loss of one *C* chromosome, (40+*C*).

3. Series γ het speltoid involved the loss of an appreciable part of one of the *C* chromosome, (40+*C*+*Cd*).

4. Sub-compactoid had a "*Cil*" chromosome; it was an "iso-chromosome" composed of a duplicated longer arm of *C*, (40+*C*+*Cil*). Rarely, similar forms were segregated with 40+*Ctl*+*Cil*.

5. "Sub-normal" mutants had a *Cil* chromosome but lacked a normal *C*. More rarely, they had two separate *Ctl* chromosomes.

6. A second type of sub-compactoid was a primary "trisomic", (40+*CCC*).

7. A third type of sub-compactoid had 40+*CC*+*Cil*.

8. The common type of compactoid had 40+*Cil Cil*, 40+*CCCC*, or 40+*C*+*Cil Cil*.

In 1948, Âkerman and MacKey (1) obtained sub-compactoids from the original *C* het speltoid. From their genetical data, these sub-compactoids were considered to have a chromosome constitution of 40+*C*+*Cil*+*Cil*, though no cytological determination was made. In following Huskins' conclusions (4), Sánchez-Monge and MacKey (11) of Sweden, determined the origin of sub-compactoids. They fonud that misdivision of the sub-medianly constricted *C*-chromosome was observed in both the first and second telophase: 1.7% and 16.0% respectively. They further postulated, without actual demonstration, that a misdivision of the *C*-univalent in a PMC of a β het speltoid, followed by a non-disjunction at the pollen mitosis of the two chromatids, derived from the long arm, would be one possible mechanism for producing sub-compactoids out of the β speltoid series. Here, of course, they referred not only to the non-disjunction of the two *Ctl* s, for actually these *Ctl* s rejoin at the centromeres to form "isochromosome". They further explained that the formation of the different types of gametes and the complicated segregation from β het speltoids were the consequence of the formation of new chromosomes following misdivision. However, no cytological data were given to substantiate this. From the earlier studies it is known that the *C*-chromosome carries the inhibitors of the genes for bearded and speltoid; furthermore, that these speltoid-inhibiting genes are situated in the distal part of the longer *C*-chromosome arm. Con-

sequently, a plant with 40+*C*+*Cil* will have three such gene sets, and will therefore behave as a sub-compactoid (Sánchez-Monge *et al* 11).

Questions would be asked therefore:

1. What is the nature or cause of speltoid formation?
2. Why should an accumulation of the inhibitng gene complexes change a speltoid into sub-compactoid and compactoids?

Probable answers to these pertinent questions are given in this paper.

MATERIAL AND METHODS

In working with monsomic IX of the variety "Chinese Spring", several plants were obtained in 1946 that had an isochromosome which consisted of the two long arms of chromosome IX. In 1947, the progeny of these plants segregated into het speltoids, normal, sub-compactoids, and compactoids. Cytological studies were carried out on several of these plants. It has been found that these plants differed in their chromosomal constitutions. Besides the regular twenty bivalents that they possessed in common, some had a telocentric chromosome; others an isochromosome; still others two isochromosomes or two isochromosomes and a telocentric chromosome. Since the population was too small, the mode of segregation was not calculated. In 1948, cytological studies were again made on the segregating lines, especially those derived from sub-compactoid and compactoid of 1947. Aceto-carmine smears were used exclusively in these studies.

OBSERVATIONS

The variation in chromosomal constitution of the plants in the different lines which were studied, and the morphological differences between them are given in Table 1.

The parents of the three segregating lines are as follows:

Parental line	Segregating line	Chromosomal constitution	Head type
1947	1948	40+	
5138—7	226	*iit*	compactoid
5138—15	228	*ii*	compactoid
5140—4	233	*it*	sub-compactoid

As the population in the three segregating lines was too small to merit an analysis of any segregating ratio, this is entirely omitted. It is appropriate here to explain the symbols for the chromosomal constitution given in Table 1 as compared with those given by Huskins (4).

Authors'	Huskins'	
IX	*C*	— monosomic
t	*Ctl*	— telocentric chromosome of the long arm of *C*.
i	*Cil*	— isochromosome of duplicated long arm of *C*.
i'	—	— a deficiency in the distal end of one arm of *i*.
f	—	— acentric fragment of unknown origin.

From all the facts so far known, it is very likely that chromosome *C* designated by Huskins (4) and other earlier workers, is the same as chromosome IX designated by Sears (13). However, no crossing experiments have yet been carried out to confirm this. The *t* and *i*, are *Ctl* and *Cil* of Huskins, respectively. They will be used for the sake of brevity in this paper.

TABLE 1. CHROMOSOMAL CONSTITUTION AND MORPHOLOGICAL DIFFERENCES OF THE PLANTS IN THE DIFFERENT GROUPS.

Pedigree	Chromosome 40+	Head type	Height of plants in cm: Plant	Height of plants in cm: Av	Length of spike in cm: Plant	Length of spike in cm: Av	Size of stomata in microns: Width	Size of stomata in microns: Length	Size of epidermal cell in microns: Width	Size of epidermal cell in microns: Length
228—2	*i*		90.5		4.4					
228—3	*i*	Het speltoid	117.0	112.0		5.9	34.08	52.34	17.28 ± 1.8	186.18 ± 65.9
228—8	*i*		130.0		7.4					
226—3	*i*		119.0		6.4					
226—8	*i*		115.0		7.5					
226—11	*i*		115.5		7.8		33.92	59.20	20.10 ± 2.6	204.00 ± 51.5
226—14	*i*	Sub-normal	115.0	113.4	6.0	6.6				
228—1	*i*		110.5		6.6					
228—13	*i*		105.5		5.3					
233—2	*i*									
233—9	*i*									
226—12	*ii*	Sub-normal	67.5		4.2					
228—6	*ii*		100.0		5.2					
228—7	*ii*		91.0		4.9					
228—10	*ii*		90.0		4.2		32.58	53.12	21.22 ± 2.3	192.74 ± 51.4
228—11	*ii*	Sub-compactoid	52.5	79.9		5.0				
228—12	*ii*		98.0		5.6					
233—5	*ii*		60.0							
233—7	*ii*									
228—5	*ii'**	Sub-compactoid	93.0		6.1					
226—4	*ii*		69.5		3.7					
226—5	*ii*		74.5		3.2					
226—6	*ii*	Compactoid	73.5	62.4	3.0	3.1				
226—9	*ii*		43.5		2.7					
226—10	*ii*		51.0		3.1		28.96	53.92	20.48 ± 2.1	139.07 ± 32.3
226—13	*iif*	Compactoid	65.0							
228—4	*iii*	Super-compactoid	64.0	64.0	3.4	3.4	30.56	57.66	21.15 ± 1.6	215.71 ± 42.5
Chinese Spring	IX IX	Normal	128.0	128.0	8.4	8.4	26.56	69.44	16.35 ± 0.8	349.44 ± 83.9
184—2	IX	Het speltoid	114.0	114.0	10.0	10.0	32.80	65.72	20.00 ± 2.7	237.60 ± 69.9
184—1	0	Speltoid	98.0	98.0	4.8	4.8	33.06	58.72	20.67 ± 2.7	174.34 ± 38.2

**i'* = deficiency in the distal end of one arm.

Cheromosomal Constitution Of Different Groups

From Table 1, it can be seen that the three segregating families segregated into five main groups, in the 27 plants that were examined cytologically. These were: Het speltoid, Sub-normal, Sub-compactoid, Compactoid, and "Super"-compactoid, and their corresponding chromosomal constitutions were, *t, i, it, ii* and *iii* respectively. Figure 1 illustrates the representative plants of the different groups picked at random, and Figure 2 the heads of the plants in front and lateral views. Plants with one isochromosome were classified as sub-normal by Huskins (4). Apart from being shorter in stature, they did not differ very much morphologically, from the normals with 42 somatic chromosomes. A single plant 226-12, with *tt*, was classified as a sub-normal, but differed greatly from all the others with one isochromosome. This plant was only 67.5 cm. tall as compared with an average of 113.4 cm. for the eight plants with one isochromosome. Also it had very few tillers which were thin, pale green, and weak in appearance. Furthermore, the heads were only half the length of an ordinary one from a plant with one isochromosome. On closer examination, the upper half of the head was not developed, and the undeveloped florets dropped off at maturity. Theoretically, plants either with two *t* or with one *i* are identical in their genetical make-up, and they should not differ from each other morphologically. That they should differ, might signify that one or both the telocentric chromosomes was deficient intercalarilly, and that this deficiency was concerned with the general vigour of the plant, but did not include the gene complexes for the head type. Other explanations are not precluded.

Plants with *it* chromosomal constitution are classified as sub-compactoid. They are typified by having a head that is compact at the terminal end, but normal in the basal portion (See Figs. 1 and 2).

One plant, 228-5, is classified as a sub-compactoid, but with an *ii'* chromosomal constitution, instead of an *ii*. Ordinarily, *i* and *i'* could not be differentiated at MI. However, at TI, when the lagging isochromosomes were dividing, a shorter arm would indicate a deficiency of the distal end. This type of deficiency had originated probably from a type of misdivision as illustrated in Figue 5, and type *d* for isochromosomes in Diagram 1. This deficiency was long enough to include the "speltoid" gene complex, so this plant was a sub-compactoid, genetically the same as *it*. Plant 226-13, had *iif* constitution and was compactoid. This additional acentric chromosome observed, was probably not part of chromosome IX, for it did not reveal any morphological variation in this plant. Perhaps it was part of a chromosome other than IX, as a result of "inversion" crossing over.

Height of Plants of the Different Groups

In a pure strain of Chinese Spring with 42 somatic chromosomes, there was a great variation in the vigour of plants as manifested by height, number of tillers per plant, and other characters. Most likely this variation was induced by soil heterogeniety, and apparently not by inherent differences. Similarly the height of the plant within a group of the same chromosomal constitution varied. It was particularly noticeable in groups with *t, it* and *ii*. However, by taking the group as a whole, a shortening effect, as exhibited by the height of the plant, was observed when the number of chromosomes increased (Fig. 1). The actual figures are *t* 112.8, *i* 113.4, *it* 79.9, *ii* 62.4, and *iii* 64.0.

There was only one plant found with three isochromosomes, but there were five with two isochromosomes. Three of the latter type of plants were much taller than the plant with *iii*, but two were shorter. As a result, the average of the *ii* plants was a little shorter than this single *iii* plant. Similarly the length of one or two spikes of plants, chosen at random from plants of different groups, was measured. The averages of these groups were: *t* 5.9, *i* 6.6; *it* 4.9, *ii* 3.14 and *iii* 3.4, (compare with Figure 2). Should we consider the hypothesis that the length of the spikes as well as the height of the plants are controlled by the "speltoid" gene complex (which is located on the long arm of chromosome IX) to be correct, as put forward by Huskins and others, then a telocentric chromosome of the long arm of chromosome IX would have one such gene complex, and the isochromosome of the duplicated long arm would have two. Consequently, this inter group variation both for the height of the plants and the length of the spike would vary inversely with the increase of the gene complexes *i.e.* dosage effect. This is indeed, found to be more or less true, as these figures are graphically represented in figure 20.

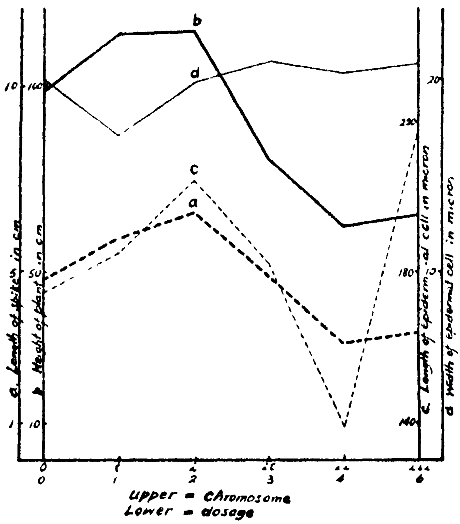


Fig. 20. Graphical representation for the length of spikes and height of plants in the plants varying in their chromosomal constitution—dosage.

A plant which is nullisomic IX, is generally weak and small. Hence it can not be compared analogously with plants with *t* s and *i* s, for it entirely lacks chromosome IX. On the other hand, a plant with *t* has only the long arm of such chromosome. That the two curves run almost parallel indicates that both the height of the plant and the length of the spikes are influenced to the same extent by the dosage effect. Starting from plants with *t* with one dosage, and ending with plants of *iii*, with six dosage, (should we have more plants of each kind, and should they be grown on a more homogeneous soil) we might get a stright-line. This point will be verified in the future.

It is very interesting to note here that plants with *t*, one dosage, were pale green in color, and had few tillers, which were slender and elongated. Furthermore, the leaves were narrower and thin. On the other hand, plant with *iii*, 6 dosages, was very stout and robust, though of short stature. Its tillers were very plentiful, but had rather short internodes. The leaves of his plant were moreover, dark green in color and were thick and wide.

Plants with *it*, three dosages, were somewhat intermediate between these two extremes. It seems, therefore, that the thickening effect on stems and leaves, and the intensifying of color vary directly with the increment in dosage. Whether or not, these factors are controlled by the same "speltoid" gene complex, or by a different gene complex or complexs, on the longer arm of chromosome IX, we are not yet prepared to

answer at present. This can be solved if detectable deficiencies for various segments of the long arm of the chromosome, can be obtained in the future.

Cell Size of the Different Groups

Should the hypothesis be correct, that the thickening and shortening of the plants are functions of the dosage effect of the "speltoid" gene complex, it follows that the size of the cells in the different groups would vary accordingly. In order to test this, leaves from plants of each group were collected at random. Unfortunately, at the time of collection, plants differed somewhat in maturity, thus sample leaves could not be collected from the same position on the plants. Consequently, a sampling error set in at the onset. Worse still, determinations were limited to only one leaf of one plant of a group instead of from several leaves of several plants of one group. However, results obtained offer some indication as to the correctness of our hypothesis. Stomata (average of 30) were measured first (Table 1). It was found that their width as well as their length vary inversely with the increase of dosage, though the latter was more variable. The sizes of the epidermal cells, in the two rows adjacent to the row where the stomata were located, were measured next. It was found that the lengths of these cells show a great variation, as indicated by the magnitude of the standard errors (Table 1). When the data are represented graphically (Figure 20) together with the length of the spikes and the height of the plants, it is found that the widths of the cells in the different groups seem to vary more or less directly with the increase in dosage. With the exception of the plant with *iii*, the curve for the lengths of the epidermal cells runs nearly parallel to the other curves for the spike and the plant. Should this be of any significance, it would mean that the thickening and shortening of the epidermal cells is again a function of dosage. Most probably the cells, especially those in the stem, (though not examined) would behave in the same way. It is clear, therefore, that the thickening and shortening of stem and spike, following the increase in dosage, are a manifestation of their cell structure. The relation of the influence of dosage, and the thickening and shortening of plant, will be fully discussed later.

Stability of Isochromosomes

As it has been demonstrated in *Zea* (Rhoades 16), in *Tulipa* (Darlintton 2, and Upcott 14), in *Fritillaria* (Darlington 3), and in *Triticum* (Huskins 4, and Sânchez-Monge *et all* 11), misdivision of a univalent either in the first or second division of meiotic mitosis, gives rise to telocentric chromosomes. Misdivision takes place more frequently in the second division in the case of wheat (Sânchez-Monge *et al* 11). These telocentrics, whether involving the long arm, or the short arm of the original univalent, are unstable. After the initial split at anaphase, either in the microspore or megaspore division, the halves are united at the centromeres resulting in a chromosome with two identical arms, isochromosomes. Some, however, divide normally, and plants with telocentric chromosomes were obtained. These plants in turn will give rise to isochromosomes as a result of misdivision, especially in anaphase II of the meiotic mitosis as well be described later.

From an initial plant with one isochromosome, plants with 0, 1, 2, or more such chromosomes can be obtained by chance and by non-disjunction; but plants

with the reappearance of telocentric chromosomes would merit careful consideration. This was exactly the case realized in the three plants obtained in 1947, which were derived from plants with one *i* in 1946, and the segrgates of the line 228 that originally had *ii*. This reversion can only be explained on the assumption that isochromosomes are unstable, and misdivisions are taking place frequently. Hence, telocentric chromosomes again make their appearance in the following generation.

In order to prove the validity of this hypothesis, plants with a single isochromosome were studied in detail. These findings are set out in Table 2.

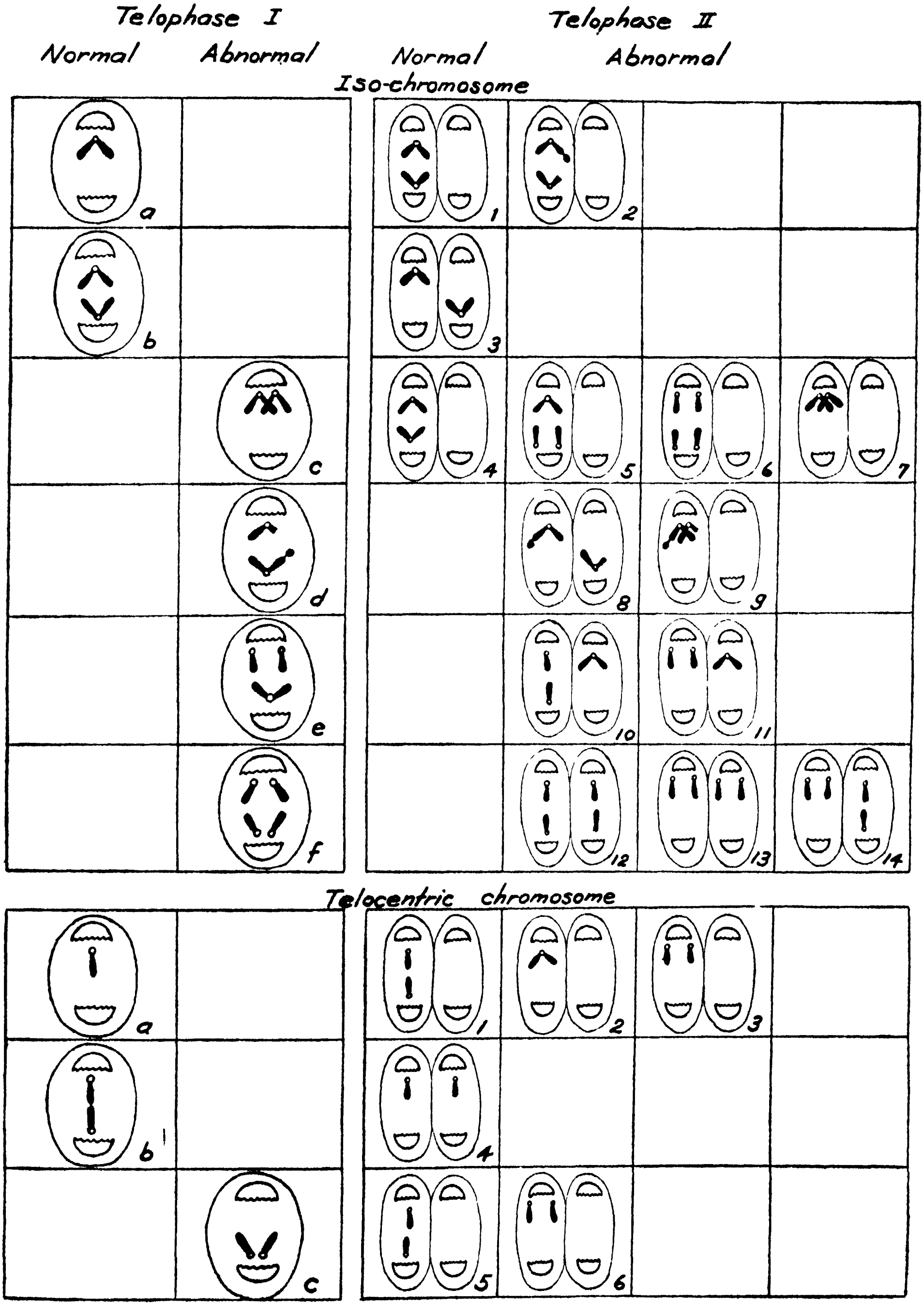
The theoretical expectancies are represented in Diagram 1 (under isochromosome). Types expected in the first telophases are designated by *a, b, c*, etc., and those in second telophase by 1 14. Type a in Diagram 1 was not scored, and it was omitted in Table 2. Sometimes the isochromosome would not lag behind on the equatorial plate, but instead it moved either with, or ahead of, the separated bivalents to the pole, making it undetectable in the first telophase. It should be pointed out here that the same picture would be obtained in a type where the halves of the longitudinally split isochromosome had reached their respective poles in time to be included with other disjoining bivalents. All other possible types were actually found (Figures 4, 5, 6, 7, and 8). That the abnormal types are more than 8% of the 103 dyads examined, is phenomenal. In type *e*, one half of the split chromosome disrupted at the centromere to form two telocentric chromosomes, and in type *f*, both do likewise to form four telocentric chromosomes. Adding these two types together, they constitute more than 5% of the toal. The frequent disruption is not only limited to the centromere region, but often (about 3%), one of the distal ends of one the arm of one chromatid was pulled off, and attached to the other (Type *d* of Diagram 1, and Fig. 5). This type of alteration of the constitution of the chromosome was depicted by McClintock (6) in *Zea*. We agree with McClintock that chiasmata formation is responsible for this kind of disruption. The release and unrevelling of the terminal chiasma is carried out with considerable difficulty. As a result, as the disjoining centromeres of the half isochromosomes pass towards opposite poles, the chromatin between the centromere and the chiasma is drawn out to a fine thread (Fig. 5). Frequently the tension becomes great enough to rupture this thread before the chiasma has unravelled and broken. Thus a deficient and a duplicated isochromosome are the final outcome. That it is this deficient isochromosome, of the distal end, that includes the "speltoid complex", is verified by the existence of plant 228-5 as described earlier. Perhaps it is a plant with 40+*CC Cil*, (4 "speltoid" doses, theoretically), that which was classified as "subcompactoid" by Huskins (4), had a deficient isochromosome. Theoretically, both arms can be made deficient as a result of chiasmata formed on both arms, but this was not observed. Plants 226-9 and 226-10 were compactoid and had a *ii* chromosomal constitution, but they were much shorter, both in height and in spike, than the other plants with *ii*. We had some suspicion that one of the isochromosomes might have a duplicated distal end. Consequently, they ought to have 5 "speltoid"—complex doses instead of 4. Unfortunately the slides made from these plants were not made permanent, and there were no comparable stages found in the remaining fixed material of these plants, so their exact chromosomal constitution could not be determined.

TABLE 2. DIVISION IN PMC OF A SINGLE ISOCHROMOSOME IN DIFFERENT PLANTS

Frequency / Pedigree	First telophase						Second telophase						
	Normal		Abnormal			Number of cells observed	Normal		Abnormal				Number of cells observed
	b*	c	f	e	d		3*	1,4	10	12	5	2	
224-1	17	5		2	1	25	20	5	2	2			29
224-6	11	1	1	1		14	15	6	1	2	1	1	26
225-9	19	3	1			23	13	1	1	5			20
226-8	6	5	1			12	11	3		1			15
226-11	16	2		1		19	17		2	1			20
226-14	2					2	9						9
229-11	12				1	13	10	1		1			12
Total	83	16	3	4	2	108	95	16	6	12	1	1	131
%	78.85	14.82	2.78	3.70	1.85		72.52	12.22	4.58	9.16	0.76	0.76	
Total	99		9				111		20				
%	91.67		8.33				84.74		15.26				

*Symbols used in Diagram 1.

Diagram 1. Possible segregation for iso- and telocentric chromosomes in telophases I and II.



In the second telophase, only some of the expected types were realized, with the exception of 6, 7, 8, 9, 11, 13, and 14. (Figures 9-15 inclusive). Perhaps this was due to the fact that the number of cells examined was insufficient. Type 5 was a result of disruption of the dividing isochromosome at the centromere region in the second division. In Table 2, types such as 3, 10, and 12, were obtained merely from the redistribution of the isochromosome, already divided or disrupted in the first division. On the other hand, types such as 1 or 4, 2 and 5, were obtained from an undivided isochromosome in the first division, and their isochromosomes were dividing at this division. In all, there were 18: sixteen disjoined normally, (types 1 or 4); one had one half of its split isochromosome disrupted into two telocentric chromosomes (type 5, roughly 5%); and the other had a half isochromosome which was difficient for the distal end of one of the arms, and the other, a duplicate (type 2, 5% roughly). From these results, we can conclude that both the disruption of the isochromosome at the centromere to form two telocentric chromosomes; and the abnormal rupture of the distal end of one arm of the dividing isochromosome (thus making one half deficient and other duplicate), can take place both in the first and second division of meiotic mitosis in the microsporogenesis, and are of approximately equal frequency. Theoretically, the same can occur equally frequently in megasporagenesis, though it was not studied. Micronuclei are undoubtedly formed from these laggards. Some of them, are able to be included in their respective nuclei. The gametes thus formed would still be functional in the egg, but competition would set in among the pollen grains with different chromosomal constitution. Perhaps pollen grains with either *t* or *i* are both functional under competition, for both of them are able to compete favorably with pollen grains having just 20 chromosomes.

Should the frequencies of the different microspores with various chromosomal constitutions, resulting from normal and abnormal division of the initial single isochromosome, be calculated from actual observation in the second telophase, (as found in Table 2) then barring exclusion by the formation of micronuclei, we ought to obtain:

Microspores with	%	ration
0	44.275	4
i	43.705	4
t	11.450	1
tt	.190	0+
i-deficient	.190	0+
i-duplicate	.190	0+
	0	

It therefore follows that the ratio for microspores with zero, those with one telocentric, and those with one isochromosome, is approximately 4:1:4. Other types are very rare, so that they are neglected in our calculation. Should the further assumption be made that: (1), there will be no further misdivision in micro- and megaspore division; (2) gametes of all types can function equally well in the egg; and (3), gametes with 20 bivalents only -zero, are non-functional under competition in pollen. Then, by using the 4:1:4 ratio calculated, we ought to obtain in the next generation, plants with the following constitution and frequencies:

Type	Frequency	%
i	16	35.55
t	4	8.88
ii.	16	35.55
it	8	17.77
tt	1	2.22
	45	99.97

We ought, of course, to have plants with very low frequencies of the other types as *tt*, *i* deficient, and *i* duplicate, either alone, or in combination with others, besides these major types.

We can conclude, that from misdivision of the unstable isochromosome, and a disruption in the centromere region, two telocentric chromosome are obtained from one half isochromosome, or four with a simultaneous disruption. This can take place either in the first or second division of meiotic mitosis with approximately equal frequency. Furthermore, misdivision as a result of obstruction by chiasma formation between the identical arms of an isochromosome will give to isochromosomes, either deficient of the distal end in one of the arms, or in a duplication. This type of misdivision will take place in both divisions of meiotic mitosis with about equal frequency. Consequently, plants with one, and only one isochromosome will, theoretically, give rise to plants in the following generation: 35% with *it*, and 9% with *t*, 35% with *ii*, 18% with *it*, and 2% with *tt*; in addition to other types mentioned above, but with negligible frequency. These types are being realized in our studies so far, and their segregating ratio will be verified later.

Mention should here be made that throughout the course of our studies, there has been no indication of a second division of the single isochromosome; either it divides in the first division, or in the second meiotic mitosis, but never twice as claimed by earlier workers.

Stability of Telocentric Chromosomes

After the midivision of the centromere at meiotic mitosis, new telocentric chromosomes are formed whose broken ends rejoin at the centromere. It may then either break again at the centromere, or pass without separation to the pole, as the new isochromosome. This was found in *Fritillaria* by Darlington (3), and in wheat, as postulated by Sánchez-Monge *et al* (11). This rejoining of the telocentric chromosome at the centromere takes place in pollen mitosis, but not before. We have shown already that the isochromosomes thus formed are not stable. They will break up into two in the following generation, returning again to telocentric chromosomes. It is of interest to follow the telocentric chromosomes to see how stable they are in the following generation. Plants with a single *t* were selected for this study. Unfortunately only one plant had the right stages for observation, so it alone was used. The results are given in Table 3 and their theoretical expectancies are represented in Diagram 1, under telocentric chromosomes (Figures 15-18 inclusive).

On account of the fact that there were only 28 first division cells studied, no reunion of the split telocentric chromosomes to form isochromosomes was observed. On the other hand, reunion was observed in four tetrads out of a total of 47 studied. Types 1 or 5, and 2 were derived from an undivided telocentric chromosome in the first division. The

telocentric chromosome involved should divide at this stage. In all, there were 9 such tetrads observed. Four of these had a reunion of the split telocentric chromosome at the centromere region (44%). This is indeed a surprisingly high percentage; nevertheless, it signifies that a chromosome with a strictly terminal centromere is highly unstable. Should we adopt the assumptions made for the isochromosomes just described, the microspores produced would be:

		%	ratio
with	0	45.8	22
	i	52.1	25
	t	2.1	1
		100.0	

The zygotes produced would be:

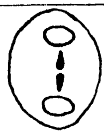
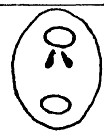
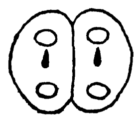
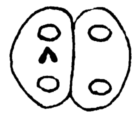
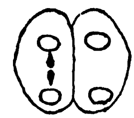
	Frequency	%
t	550	44.07
tt	625	50.08
i	22	1.76
it	50	4.01
ii	1	.08
	1248	100.00

That this calculation is based on an observation of less than fifty cells certainly makes it unreliable. It reveals, however, that isochromosomes can be obtained through the reunion of the longitudinally split telocentric chromosome in the centromere region. This takes place mostly, if not exclusively, in second division of PMC. From the study of the isochromosomes, we have pointed out that they are also unstable. Frequently they disrupt at the centromere region to revert to the telocentric chromosomes. This process is certainly reversible, but each change seems to take place in the division of PMC or EMC in the succeeding generation. We know that the reunion of telocentric chromosomes can occur in meiotic mitosis in the microspore; though it is unknown whether the disruption of isochromosomes can take place there also. This is a point that needs further investigation. Furthermore, will this union and break cycle be true in somatic mitosis? If so, the plants will show a mosaic or chimera effect. This probably offers an explanation for the vulgare-speltoid chimeras found by Âkerman, Kajanus, and others, and for the het speltoid, sub-compactoid chimeras found by Lindhard and Ishikawa (*cf.* Hiskins 4). The disruption of an isochromosome, or reunion of a telocentric chromosome, both taking place at the centremere region in somatic mitosis, will undoubtedly give rise to plants with either mosaics or chimeras. Consequently the disruption and reunion cycle would take place, though its frequency is still unknown in somatic mitosis in sporophytic tissues.

If this is true, it differs greatly from the break-fusion-bridge cycle as described by McClintock in *Zea*, (McClintock 5, 6, 7, and 8). This cycle, according to McClintock, is confined only to the gametophytic and endosperm tissues in the generation immediately following the meiotic origin, and it ceases in the sporophyte tissues and never reappears. Moreover, the recovered broken chromosome is as permanent in its morphology as any normal chromosome of the complement. In *Triticum*, the centromere region of the long arm of chromosome IX is unstable particularly in the strain we used in these studies. It reunites after the longitudinal split, or is split up again into its original

form; this splitting would occur in meiotic division, or possibly in post-meiotic division, or even in mitosis in sporophytic tissue. This process repeats itself again and again, as long as this broken region is not mended or modified. Caution should here be indicated that any generalized statement concerning only chromosome IX of wheat, would be fallacious and misleading. It may be that the same disruption and reunion can occur in chromosome VI, but it is certainly not true of chromocome X of wheat (unpublished results).

TABLE 3. DIVISION IN PMC OF TELOCENTRIC CHROMOSOME.

Frequency / Pedigree	Telophase I		Telophase II		
	Normal	Abnormal	Normal	Abnormal	
	 b*	 c	 4	 2	 5*
228-8	26	2	38	4	5
Total	28		47		
%	92.86	7.14	80.85	8.51	10.64

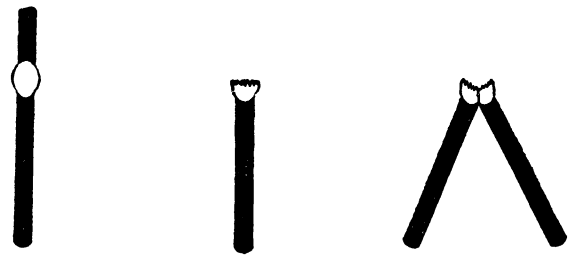
*Symbols used in Diagram 1.

The next questions to be followed are:

1. What is the nature and structure of the centromere?
2. Why is a chromosome with a terminal centromere unstable?
3. Why is it also, that an isochromosome with a median centromere is unstable?

Rhoades (10), Darlington (2), and particularly Schrader (12) offered ingenious hypothesis to explain the structure of the centromere and its behavior during mis-division; but until we know precisely the structure and behaviur of the centromere, we cannot draw any definite conclusion. However, it is safe to say that the broken centromere, after mis-division, is not satisfied with the part that is left after its initial wholeness is impaired; nor is the part-centromere enough, either quantitatively or qualitatively, to carry the burden of the movement of the chromosome, which was carried originally by the entire centromere. In order to meet the requirement of sustaining this heavy burden, there must be a resumption of its former size; so that when the chance comes, two broken centromeres in the dividing telocentric chromosome will reunite to form the isochromosome. This is still not quite satisfactory however, for if our theory should hold, the reunited centromere, either remains, for *a priori* reasons, still insufficient to carry the burden of movement of the newly formed isochromosome; or its union at the centromere is so imperfect that it is liable to break up at any movement. As a result, whenever the opportunity occurs, this reunited centromere region is again disrupted in division. Thus the disruption and reunion cycle goes on indefinitely. (Diagram 2)

Diagram 2. Diagramatic representation showing the probable structure of the centromere in misdivision of Chromosome IX (centromere is exaggerated).



Chromosome IX Telocentric chromosome Iso-chromosome

It would be of interest to see whether an unsatisfied broken centromere of a telocentric chromosomes is liable to unite with another, say one from male gamete and another from female gamete, as McMlintock (1902) positively demonstrated with broken ends of "chromosome 9" in *Zea,* though this is yet to be carried out.

If this unstable chromosome can reunite and break up during division in successive generations, it would show why segregating ratios could not in the past, be explained for sub-compactoid which has *it* (*cf.* Huskins 4). This can be solved if the types of gametes, and the number of functional gametes are known, and then the segregating ratio can be calculated. It is hoped that we shall be able to verify this in the future.

DISCUSSION

From our studies, we agrees with Huskins and others (Huskins 4) that the change from speltoid to compactoid is directly proportional to the presence of the number of doses of the "speltoid" complex that are located in the distal end of chromosome IX. This "speltoid" complex was postulated to have speltoid-inhibiting genes. Accumulation of these, above 3 doses in a plant, would change it into compactoid (Sánchez-Monge et al 11). It is true that this, as far as it goes, fits the observed facts, but as it is rather vague, we venture to offer as alternative explanation in its stead.

Growth of plant, and particularly the elongation of the cells, which directly concern our problem here, is governed by auxin (Went and Thimann 16). The dwarf type of corn, *nana,* differs from the normal by a monohybrid gene, and the growth rates, especially those of the mesocotyl and stem, are greatly reduced. The seedlings of *nana* were found to produce less auxin than the normals, and also to respond less to applied auxins. Since their relative auxin production and their sensitivity to applied auxin were the same, namely 55% of the normal, Van Overbeck (15) concluded that both these effect were due to an increased power of an inactivating auxin. This was proved directly by measurements of auxin inactivation. Mesocotyl sections of *nana* inactivated about twice as much auxin as the normal. This inactivation was possibly due to higher peroxidase activity in *nana* than in the normal. In dwarf races more extreme than *nana,* having both coleoptile and mesocotyl greatly reduced in length, a correspondingly still smaller production of auxin has been found.

If the findings for dwarf types of corn can be applied to wheat then we can immediately visualize that the "speltoid" complex is not concerned with the production

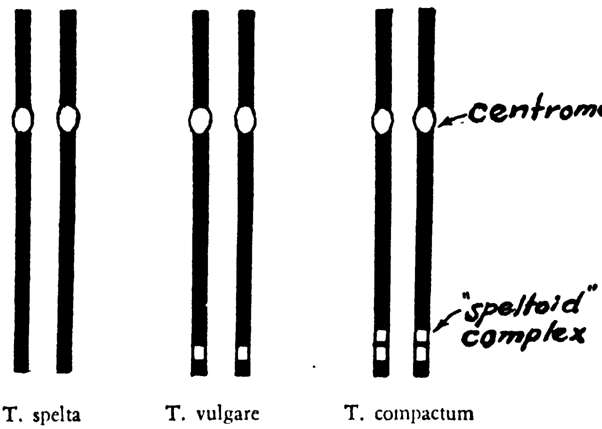
of auxin: rather it is concerned with the inactivation of auxin, produced by gene complexes on other chromosomes of the hexaploid wheat. This inactivation of auxin through oxidation is cumulative in its effect. That is to say, each dose will only inactivate auxin to a certain degree, and the higher the accumulation of this "speltoid" complex in a plant, the more auxin is inactivated, hence the more dwarf is the plant and the more compact is the head. This dwarfing effect is strictly a matter of shortening of the internodes in these plants; and this in turn is directly concerned with the non-elongation of the cells in these tissues. That elongation of the cells is regulated by the presence of auxin is well known, though the precise nature of this elongation is still somewhat obscure. We have found from the measurement of the length and width of the epidermal cells in plants with different doses (Table 1), that these measurements agree, more or less, with the hypothesis. Though the determination of the amount of auxin in the plants with different doses, has yet to be carried out, we think that this hypothesis promises a nice fit with the cytogenetical findings in speltoids and compactoids of wheat.

Plants nullisomic for chromosome IX (0 dose) are speltoid. According to the hypothesis, the auxin content would not be reduced through oxidation, because of the absence of this "speltoid" complex, and the plant should be very tall, and its spikes very lax; factors proportional to the amount of auxin present. Contrary to expectations, though the plant has a very lax head, it is weak, slender, dwarf, and pale looking. In all probability, this weak growth is a result of the absence of some other factors essential for growth which are located on chromosome IX, particularly on its short arm. This is supported by the evidence of the rather weak growth of plants with only a telocentric chromosome consisting of the long arm. In contrast to this a homozygous speltoid of the α type, which does not have the "auxin inactivator", but otherwise has two complete intact chromosome IX, is like *T. spelta,* from which the name speltoid was originally derived (Speltoid of α type may have a undetectable deficiency according to Huskins, 4). On the other hand, het speltoid with only one chromosome IX, is about as tall, or a little taller than, the normals with 42 chromosomes. It may be that the lesser extent of inactivation of the auxin with one dose is compensated by the lack of other factors for growth and that this is more or less cumulative when only one chromosome is present as is the case of het speltoid compared with the normals. Similarly we can explain the weaker growth of plants with *t* only, except that here it is also handicapped by the absence of the short arm of chromosome IX. Plants with 42 chromosomes and plants with *ii* are normal, but the latter, are comparatively shorter (Table 1). As far as the "speltoid" complex is concerned, both types are equal, but plants with *ii* are again handicapped by the absence of the short arm of chromosome IX. A further accumulation of the "speltoid" complex doses would induce more inactivation of auxin, resulting in the condensation of the spikes, the shortening of the internode, and at the same time, the thickening of the stem and leaves. In our study, a plant with *iii,* 6 doses, was met with; plants with 6 doses were the highest recorded in the diagram of Huskins (4). It is therefore interesting to see whether plants can accumulate still higher doses, when the shortening and thickening effects would be at their maximum, yet without threatening the very existence of the plants. With chromosome VI, we

have plants with *iiiit* (unpublished deta). Since we could not detect any dosage effect with this chromosome, it is rather doubtful whether we can obtain plants with chromosome IX in higher doses than six. This however, will be verified in the future.

Should there be any truth in our hypothesis, that the manifestation of speltoid, normal, and compactoid is a function of dosage of the "speltoid" complex, then it follows that the origin of the three species of wheat can be explained by analogy: *Triticum spelta* would have 0 dose, *T. vulgare* 2, and *T. compactum* 4 doses. (Diagram 3.)

Diagram 3. Theoretical dosages of "speltoid" complex in wheat species.



Should the progenitor of these three species be a type of the order of *T. vugare,* then an unequal crossing-over of this very gene-complex would result in gametes with two and zero gene complexes. Zygotes obtained consequently would be *T. compactum* and *T. spelta.* It should be recalled that the artificially synthesized hexaploid wheat, from *T. dicoccoides* and *Ae. squarrosa,* by McFadden and Sears (9), was *T. spelta.* Thus, it may be assumed, that in the course of time a mutation arose which involved a gene for the oxidation of auxin. This was the origin of *T. vulgare,* with its two doses. Later, by unequal crossing over, *T. compactum* was derived, with its four doses.

The validity of the above hypothesis could be established by:

1. actual demonstration of the amount of auxin present in each species; and

2. by converting the long arm of chromosome IX of *T. spelta* and *T. compactum* to isochromosomes, and at the same time, back-crossing these species to "Chinese Spring" for several generations, so that a uniform background for the genes on the other twenty pairs of chromosomes is obtained, while the isochromosomes are accumulating. Theoretically the accumulation of isochromosomes derived from *T. spelta,* would have no effect either on the lengthening or on the dwarfing of the plant. On the other hand, one isochromosome derived from *T. compactum* would have four such doses, and the resultant plant would be compactoid. An accumulation of two isochromosomes would give 8 doses, and the plant would be "super-super" compactoid, should such a plant be able to survive.

Work on these lines is in progress, but it will take several years before a tiue answer can be obtained.

From a personal communication, Dr. Sears has informed us that the gene for the compactum type is on chromosome XX, but he mentioned no reference. According to our experience, and from the description of Sears (13), nullisomic XX is very similar to nulli-II, except that it is slightly more vigorous, less coarse, and slightly female-fertile. Nulli-II has a much reduced tillering, and a delayed maturity, also it has short and thick culms and broad leaves; its spikes are short and thick. Furthermore according to Sears (13), chromosome II and XX can compensate each other. *T. vulgare* is a hexaploid which is derived from three progenitors. Each must carry a gene or genes for the production of auxin. When these three distinct progenitors are brought together to the new hexaploid, the genes for auxin production would become additive, unless some mutation should take place. We have postulated that chromosome IX carries the "speltoid" complex, which has the function of inactivating auxins which are produced by genes on some other chromosomes. It seems that the site of these genes for auxin production, is probably located, either on chromosome XX, or on both XX and II. An absence of chromosome either XX or II indicates a reduction in auxin production, accompanied by a shortening and thickening effect. On the ather hand, the accumulation of auxin would result in the lengthening and attenuating effect tending towards spelta. Such a result would be in accord with our hypothesis, but its validity hangs on our future result.

SUMMARY

From the misdivision of monosomic IX of "Chinese Spring", an isochromosome which had the duplicated long arm was obtained. In the second generation following the initial appearance of the isochromosome, plants were obtained with one telocentric, one iso-, one telocentric- and an iso-, two iso- and three iso- chromosomes. This increment of chromatic material in the plant is closely associated with changes in its morphology; from speltoid plants with lax ears, tall slender stems, and pale green leaves to compactoid plants with compact spikes, short stout stem, and thick broad leaves of dark green color.

Hence, the change from speltoid to normal and to compactoid is a function of the dosage of the "speltoid" complex, which is located in the distal end of the long arm of chromosome IX. The proof for the latter was obtained by the occurrence of one sub-compactoid plant with two isochromosomes, but having a deficient segment in the distal end of one of the arms of one of the isochromosomes. The shortening and thickening effect on the plant, following the increase of the dosages of the "speltoid" complex, was associated more or less with the shortening and broadening of the epidermal cells. It was postulated therefore, that the "speltoid" complex is a genic complex which resembles *nana,* the dwarf mutant of corn, and which has the power of inactivating auxin. Its effect is cumulative. The higher the dosage of this gene complex, the more auxin is inactivated; hence, effecting an increased dwarfing and thickening in the plant. It was further hypothesized that *T. spelta, T. vulgare,* and *T. compactum* differ in their dosages of this gene complex with, respectively, none, two, and four doses. The change in the doses in these three species was probably the result of gene mutation followed by an unequal crossing-over.

Isochromosomes which were found to have the chromosome disrupted at division in the centromere region, reverted to telocentric chromosomes. This disruption takes place in both the first and second meiotic mitosis with approximately equal frequency.

Telocentric chromosomes were also often found to have centromere end reunited, reverting to isochromosomes again during the second meiotic mitosis. This reversible change probably does occur in the sporophyte tissue, and may also take place in post meiotic mitosis in gametophytic divisions.

As a result of crossing-over between the duplicate arms of the isochromosome, chiasmata were frequently formed in either the first or second meiotic mitosis. The abrupt rupturing of the disjoining halves of the isochromosome before the chiasma had a chance of unravelling or of being broken, resulted on the one hand in a deficient distal end, and on the other a duplicated distal end.

This deficiency of the distal end of the isochromosome was realized in the plant with *ii* constitution, but instead of being a compactoid as expected, it was "sub-compactoid".

Acknowledgement: To Dr. Sears of the University of Missouri, who furnished the original seeds of Monosomic XI, the authors owe their gratitude.

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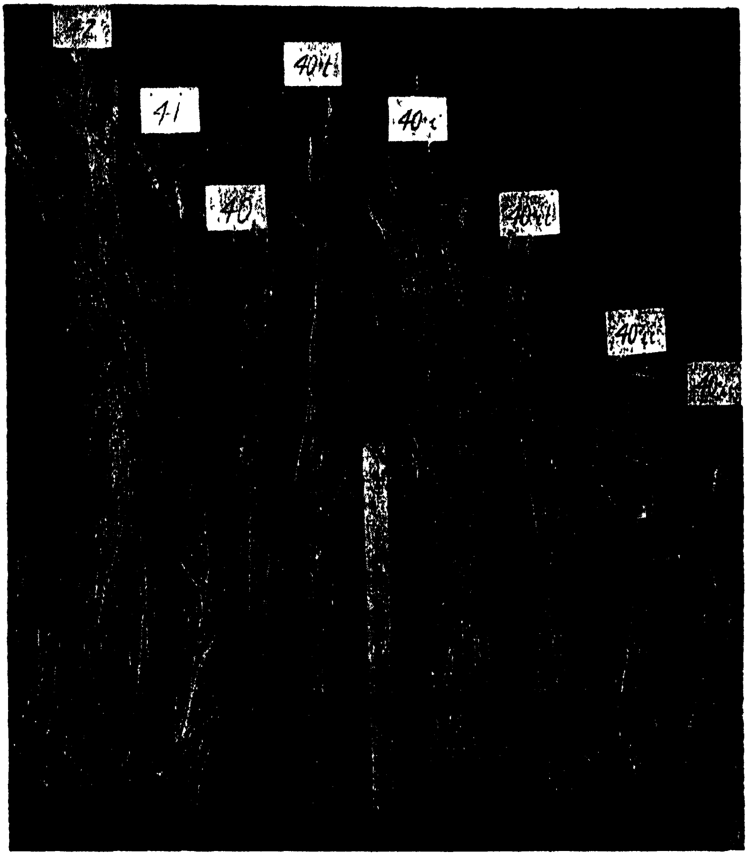


Figure 1. Plants with varying chromosomal constitution.

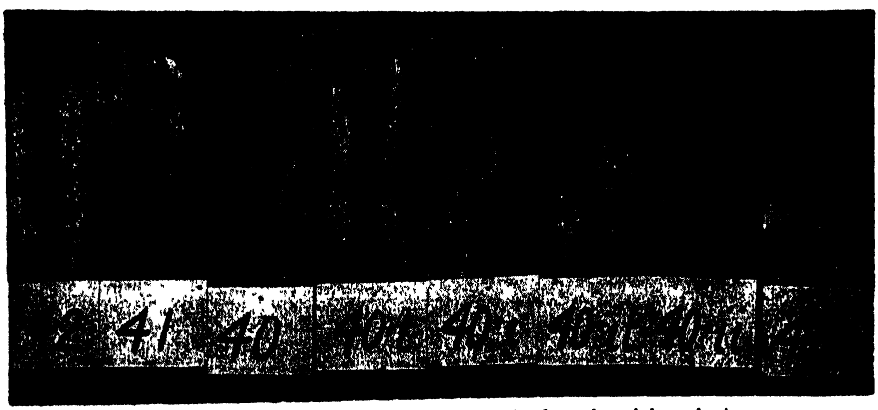


Figure 2. Heads of the same as in Fig. 1 in frontal and lateral views.

EXPLANATION OF FIGURES

(Fig. 4, 5, 6, 7, 8, and Fig. 3, c, d, e, f, and g. 860X other, 900X except explained otherwise).

1. Photographs of whole plants with varying number of chromosomes. Beginning from left; 42, 41, 40, 40+*t*, 40+*i*, 40+*it*, 40+*ii* and 40+*iii* respectively. A 2 feet ruler, in the middle for comparison.
2. Photographs of the heads of the plants shown in the above photograph, about half natural size.
3. a. Univalent chromosome IX found in first metaphase in 184-2, showing sub-median constriction.
   b. The same, lagging on the equatorial plate in first telophase. The chromatids, after longitudinal split are moving toward their respective poles and are led by their centromeres.
   c.-g. Extra chromosomes on top of the regular 20 bivalents found in first metaphase in different plants.
   c. A telocentric chromosome in 228-2.
   d. An isochromosome in 228-13.
   e. A telocentric and an isochromosome in 228-10.
   f. Two isochromosomes in 226-10.
   g. Three isochromosomes in 228-4.

4.-8. Longitudinally and transversely split chromatids of an isochromosome disjoining at the equator in first telophase.

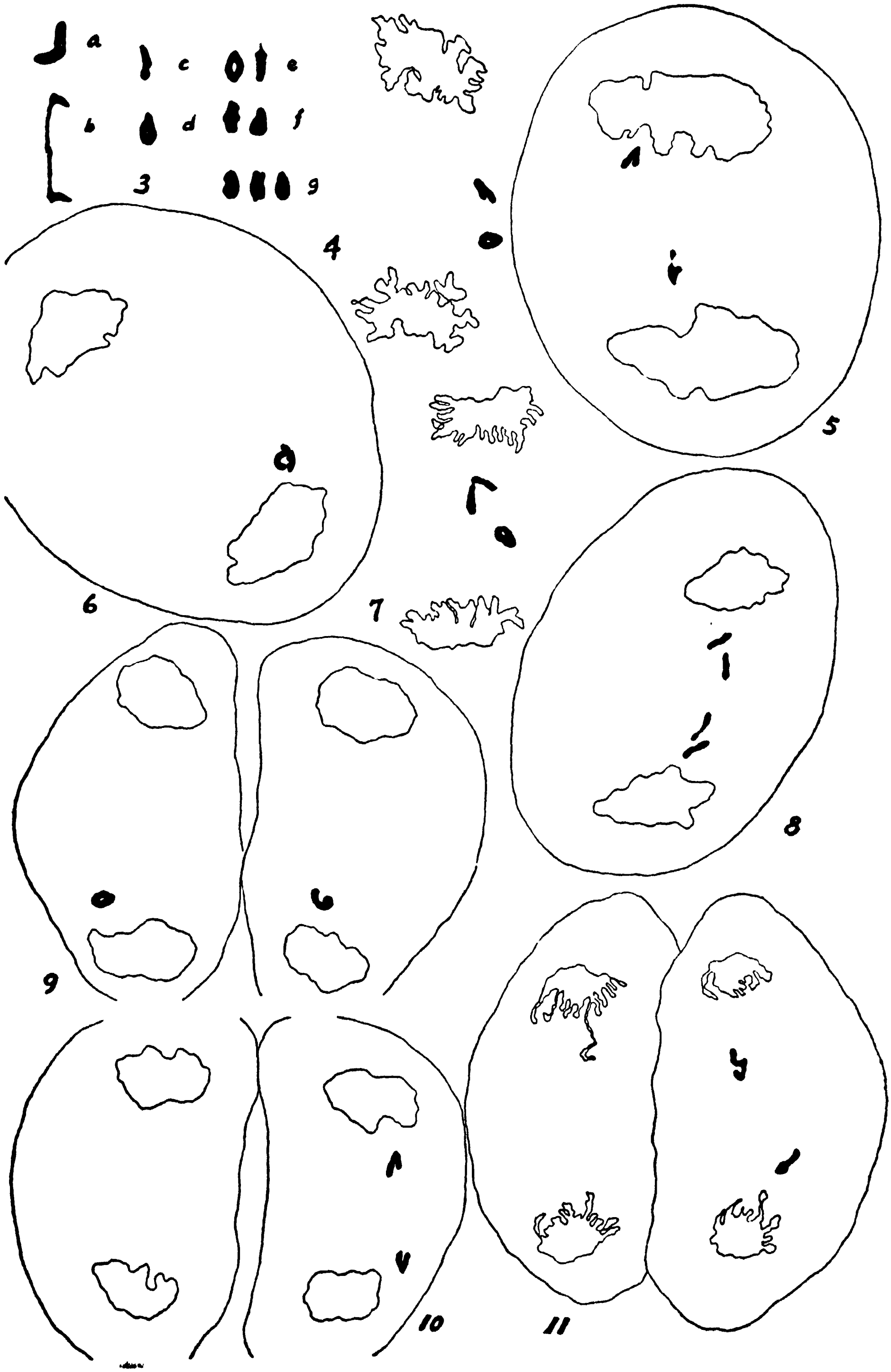
4. Normal disjunction, one to each pole (225-9).
5. Abnormal separation found in 224-1. Part of the distal end of the arms of the upper chromatid is detached in separation and attached to the lower chromatid.
6. Both chromatids going to one pole (224-6).
7. The upper chromatid is detached at the centromere. A thin connecting thread is still visible. This transverse break at the centromere will give rise to two telocentric chromosome (224-6).
8. Both chromatids are transversely broken at the centromeres given rise to four telocentric chromosomes; two going to each pole (226-8).

9.-14. Division and separation of isochromosome in second telophase.

9. One chromatid is distributed to each sister cell of the tetred after normal disjunction in first telophase (224-1).
10. Normal disjunction of chromatids to their respective poles in one half of the tetrad (224-1).
11. Both chromatids are in one sister cell of the tetral. The upper one is transversely split at the centromete given rise to two telocentric-chromosomes (224-6).
12. Two telocentric chromosomes are distributed to one sister cell of the tetrad, and one isochromosome to the other.
13. The upper chromatid has split transversely in two telocentric-chromosomes in one sister cell of the tetrad. The lower half remains intact (224-8).
14. Four telocentric chromosomes resulted from misdivision in first telophase as shown in Fig. 8 are distributed to both sister cells of the tetral. Presumably, one goes to each pole (114-1).

15-19. Separation and reunion of telocentric chromosome in first and second telophase.

15. Normal disjunction of a telocentric chromosome after longitudinal split in first telophase. Each chromatid goes to their respective pole (228-8).
16. One chomatid is distributed to each sister cell of the tetrad (228-8).
17. Normal disjunction of telocentric chromosome in one sister cell of the tetrad following non-division in the first telophase (228-8).
18. Londitudinal split of the telocentric chromosome in one sister cell of the tetrad. Instead of separating, these two chromatids are reunited at the centromere to form one isochromosome (228-8).
19. The same. Centromere pulling this chromosome ahead is clearly located at the median region (228-8).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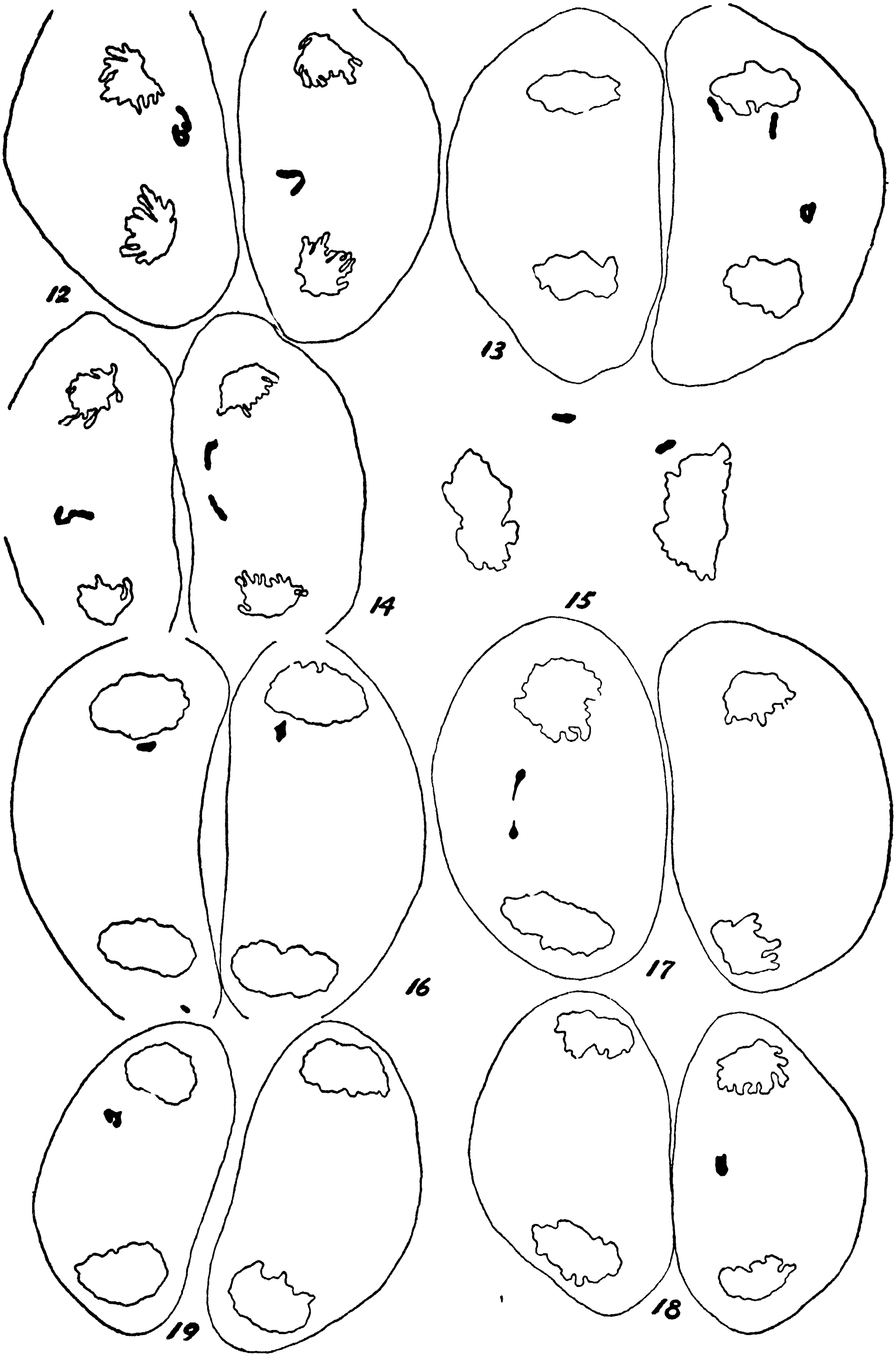
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THE EFFECTS OF CLAVACIN UPON ROOT GROWTH

F. H. Wang

Clavacin, an antibiotic substance from *Aspergillus clavatus,* is found to be active against both gram-negative and gram-positive bacteria and fungi but it appears highly toxic to animal organism (2,5). So far as the author knows no study has ever been made on plant growth and cell division effected by clavacin. This paper presents the experimental results on the physiological and cytological effects of clavacin upon roots.

MATERIAL AND METHODS

The clavacin was obtained in purified crystal form. Corn and onion were tested. The first generation single cross, 1943 corn seed, of pedigree WF9 x 38-11, was used. The onion bulbs were obtained from the market. The corn kernels were soaked overnight in distilled water and then put in Petri-dishes on filter paper for germination at room temperature (70-74° F.). When the roots had attained about 10 mm. in length, the germinated seeds were transferred to 120 cc wide mouth bottles containing Shive nutrient solution (4) or different concentrations of clavacin in nutrient solution. The mouth of the bottle was covered with paper perforated and infiltrated in paraffin. Five plants were planted in each bottle; and a number was given to each plant. The length of roots were measured at definite time interval with a calibre. The onion bulbs germinated in tap water and some of them were treated with clavacin solution. Both roots of corn and onion were fixed in Randolph's modification of Navashin fluid, stained either in iron-alum haematoxylin and gold orange, or safranin and fast green (1). The drawings were made with the aid of a camera lucida.

EFFECTS ON GROWTH-RATE OF CORN ROOT

Table 1 shows the growth-rate of corn root with the concentration of clavacin varied from 1/50,000 to 1/1,000,000. The clavacin becomes fatal to the corn at the concentration above 1/200,000. It apparently inhibits the growth of the root and the degree of inhibition increases with the increase in the concentration of clavacin. The concentration at 1/200,000 is the landmark. At this concentration or higher the plants grow, if any, but little. The symptom of injury at first appears at the hypocotyl. Gradually the root becomes shrunk and stops to grow; then it becomes soft and pale, and in most cases, finally succumbs to death.

Table 2 shows the experimental results with closer intervals of concentration of clavacin from 1/200,000 up. During the first 48 hours of growth, 10 out of 15 plants in 1/200,000 clavacin solution were badly injured but some of them recovered and resumed their growth during the later 48 hours. The plants grown in solution higher than 1/200,000 never recovered once injured. The resistance to toxicity is inconsistent. Some individuals are apparently more resistant than others, but the number of surviving plants, at the end of 192 hour of growth, decreases with the increase of concentration of clavacin. The plants that survive become woody and pale with various rate of growth, sometimes the root tip curls up.

Table 3 shows the data of experiments with closer intervals of concentration at and below 1/200,000. Again, most of the plants grown in 1/200,000 clavacin were injured, and some of them recovered but made little growth and became woody.

TABLE 1. GROWTH OF CORN ROOT AT DIFFERENT CONCENTRATIONS OF CLAVACIN IN NUTRIENT SOLUTION.

Time / Conc.	Initial length	24 hours growth	48 hours growth	72 hours growth
1/50,000	9.4 mm.	10.3	11.2	11.5
1/100,000	8.2	9.5	10.1	10.3
1/200,000	9.2	11.8	12.6	14.5*
1/500,000	9.3	12.5	17.0	32.1
1/1,000,000	8.4	13.4	20.6	37.4
control	9.5	16.7	28.6	51.4

* Only one plant grows more or less normally.

TABLE 2. GROWTH OF CORN ROOT IN RESPONSE TO THE HIGHER CONCENTRATIONS OF CLAVACIN.

Time	Initial length	24 hours growth	48 hours growth	Survivals at end of 192 hours	
Conc. ..				No. plants	%
1/50,000	10.4 mm	10.5	10.5	0	0
1/75,000	10.5	11.4	11.4	1	6.6
1/100,000	10.1	10.8	10.8	1	6.6
1/150,000	9.8	11.1	13.6	4	26.6
1/200,000	10.6	13.3	15.4	11	73.3
Control	10.9	17.9	27.8	15	100

TABLE 3. GROWTH OF CORN ROOT IN RESPONSE TO THE LOWER CONCENTRATIONS OF CLAVACIN

Time	Initial length	12 hours growth	24 hours gr owth	36 hours growth	48 hours growth	Injured plants after 144 hours	
Conc.						No.	%
1/200,000	11.9 mm	14.4	14.6	14.6*	14.8*	6	60
1/400,000	11.6	15.1	16.9	20.1	23.5	1	10
1/600,000	11.8	15.3	18.2	22.4	27.4	2	20
1/800,000	11.8	15.6	18.7	23.6	28.9	1	10
1/1,000,000	11.4	14.9	17	21.2	25.8	1	10
Control	12.4	16.9	20.9	26.4	32.1	0	0

* Only one out of ten plants grows from 15 mm. to 16.7, then to 19 mm.

Table 4 shows the after-effect of clavacin treatment. After four hours treatment of the germinated corn seeds, they were washed in distilled water and then transferred to the nutrient solution for culture. The growth-rate decreases with the increase in the concentration of clavacin. If the plants were transferred to the tap water instead of nutrient solution for culture, most of them stopped to grow but developed abnormally—curling up of the tips, dying off of the root cap, production of numerous rootlets, etc.—or died off, even if the time of treatment is reduced to two hours. The effect of clavacin is decisive.

TABLE 4. GROWTH-RATE OF CORN ROOT AFTER 4 HOURS TREATMENT WITH CLAVACIN SOLUTION. (AVERAGE OF 5 PLANTS)

Time	Initial length	24 hours growth in nutrient solution	48 hours growth in nutrient solution	72 hours growth in nutrient solution
Conc. of clavacin treatment				
1/10,000	11.2 mm	18.4	33.7	43.7
1/50,000	11.3	23.7	47.0	69.2
Control	10.1	25.3	50.6	79.0

EFFECT ON ROOT TISSUES

From prepared slides of corn roots the following observations were made. After 24 hours of growth in clavacin at the concentration of 1/200,000, severely injured or dead cells first appeared in the peripheral layers of root cap and epidermis. These cells were easily identified by their reaction to haemetoxylin stain, as both cytoplasm and disorganized nucleus were stained dark and became obscure in appearance. No cytological change was detactable at concentrations beyond 1/200,000. This cytological phenomenon of injury agrees with the growth-rate experiments described above. In case of 1/100,000 clavacin with 24 hours growth, dead cells were found in the root cap, the epidermis, and the layer next to epidermis. Then the remaining cells became more or less vacuolated in comparison with those of the control. The vascular-initials and meristem tissues were the least affected. In case of 1/50,000 clavacin with 24 hours growth, the outer cells of the root cap and epidermis and the layer beneath were mostly dead, while all the cells in other places became vacuolated. In certain cases, the epidermis was broken off here and there and the dead cells were found inside. The injury or death of cells in the root cap and the epidermis, and the vacuolation of the tissues beneath were already observed in case of 12 hours growth at the concentration of 1/50,000. In a word, the longer the treatment and the higher the concentration, the more dead cells and vacuolation result. The injury progresses from root cap, epidermis and the layer beneath to the cortex-tissue, the central tissue, vascular initials and the meristem. The root meristem is well protected and is the most active tissue, it is also the least and may be the last vulnerable.

In case of onion root tip, the cells are highly vacuolated in the region of meristem treated with 1/10,000 clavacin for 8 hours, while those in the untreated plant are not so characterized (figs. 1 and 2). In dividing cells no significant change of the prophase, metaphase and anaphase chromosomes was observed, but the chromosomes may stay closer together and lose their individuality due to the vacuolation of the cytoplasm (fig. 3). At the stage of anaphase, however, failure of wall formation may result in the binucleate cells (figs. 4, 5 and 6). The frequency of cell division is not effected by the action of clavacin, as no significant difference has been obtained from counting. Though the cytoplasm is going to be abnormally vacuolated, the nucleus is still going to divide as usual.

DISCUSSION

Clavacin is very toxic to plant cells, since at the concentration of 1/200,000 it is still fatal to the corn plants. The effect on the growth-rate may be detectable at a dilution as low as 1/1,000,000. Sometimes the plant may recover from the injury and develop certain kind of resistance by turning woody. It is quite interesting to know that the most sensitive part of the seedling is the hypocotyl. The root meristem is the last tissue to be effected by clavacin, while the root cap and the epidermis easily die off. The vacuolation of the cells may be due to the physiological stimulation by clavacin. Since vacuolation is a process of maturation in most plant tissues, its occurrence suggests that the stimulation by clavacin may bring about the prematurity of cells.

The inhibition of the wall formation by clavacin is very interesting. While colchicine induces polyploid cells by inhibiting the spindle formation (3), clavacin causes the cytoplasm to become vacuolated but does not seem to affect the behavior of chromosomes

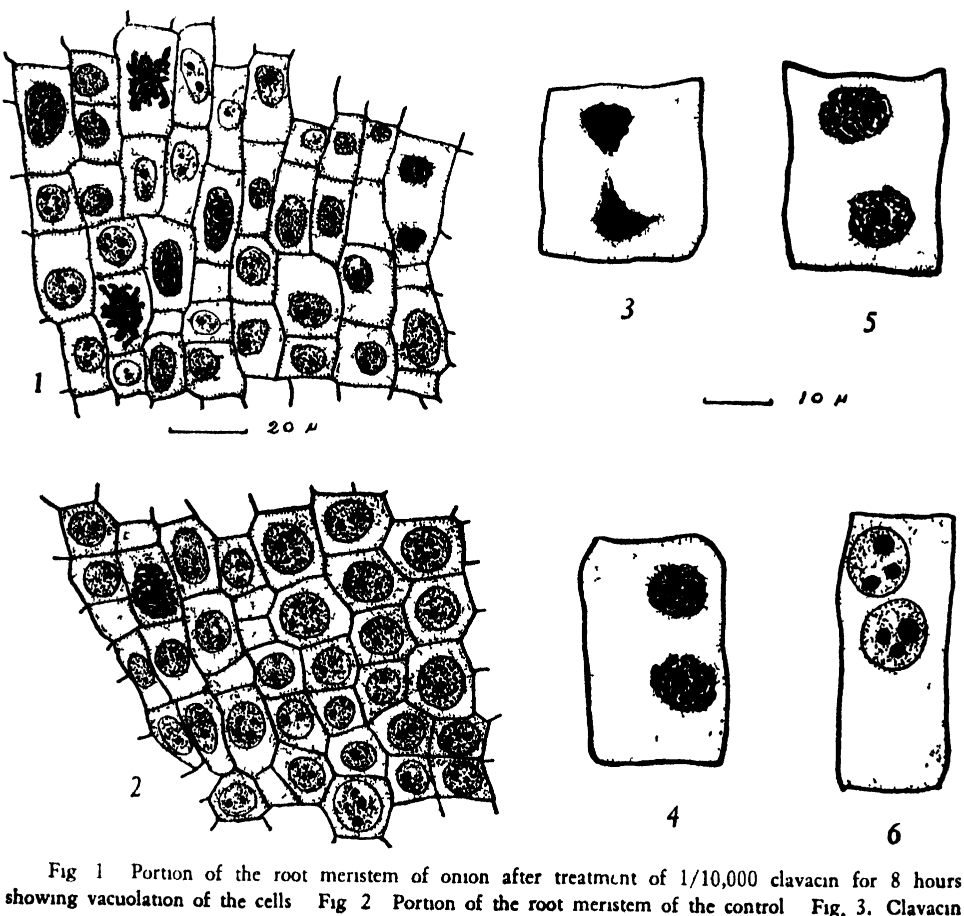

Fig. 1. Portion of the root meristem of onion after treatment of 1/10,000 clavacin for 8 hours showing vacuolation of the cells. Fig. 2. Portion of the root meristem of the control. Fig. 3. Clavacin treated dividing cell at amaphase with crowding of chromosomes due to vacuolation. Fig. Fig. 4 and 5. Clavacin treated dividing cells at telophase failed to form cell wall. Fig. 6. Binucleate cell from clavacin treated onion root tip.

SUMMARY

Clavacin is very toxic to plant cells at concentration 1/200,000 or above. It inhibits the growth of corn roots at dilution as low as 1/1,000,000. The injury of the corn root caused by clavacin is shown by dead cells in the root cap and the epidemis and by the vacuolation of the other tissues. Clavacin may inhibit cell wall formation resulting in binucleate cells but it does not seem to affect the chromosome behavior in cell division.

The author wishes to express his thanks to Dr. W. H. Anderson of the University of Illinois, U.S.A. for his helpful suggestions and criticisms during the progress of the work.

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THE EMBRYOGENY OF TORREYA GRANDIS

S. H. Tang

Morphological studies on the genus *Torreya* of the family Taxaceae have been reported by several investigators. As early as 1904 Miss Robertson (6, 7) made a series of morphological contributions on *Torreya californica.* Coulter and Land (3) described the gametophytes and embryo of *T. taxifolia* in great details in 1905. The embryogeny of *T. nucifera* and *T. igaensis,* two Japanese species, has been reported by Tahara (8, 9). Almost at the same time Buchholz (2) published a thorough investigation in the embryogeny of *T. californica, T. taxifolia* and *T. nucifera* with some considerable differences from Tahara's (8) observations.

According to Hu's (4) description three species of *Torreya* were recorded in China, namely: *T. jackii, T. fargesii* and *T. grandis.* However, none of these three species has been studied morphologically. The present paper describes the embryogeny of *T. grandis.*

MATERIAL AND METHODS

The material used for present study was collected from the trees growing in the Jessfield Park, Shanghai. The collections were made in 1947 and supplemented in 1948. The fresh material was fixed in formalin-acetic-alcohol as well as in Derman's modification of Navashin's fluid. The usual paraffin method was employed for proembryo stages and part of the material in the later stages. Sections of 8 or 10 microns in thickness were stained with Heidenhain's iron-alum-hematoxylin and some of them were counter-stained with safranin or gold orange. For the stages following the elongation of pro-suspensor, the Buchholz (1) method of dissection and total mount was followed.

OBSERVATIONS

The archegonia of *Torreya grandis* are usually one in number, rarely two or three. In a count of forty ovules 36 had 1 archegonium, 3 had 2, and 1 had 3. There is no jacket layer around the archegonium though several small cells which may be considered as scattered jacket cells are present. But no dense cytoplasm or conspicuous nuclei were found in these cells. Shortly before fertilization a ventral canal nucleus is formed just as Tahara (8) described in *T. nucifera.* The division figure of the central cell has not been observed while figure 1 shows a little later stage in which the ventral canal nucleus has been already cut off.

Pollination takes place in early April while fertilization occurs at the end of April or the first week of May. The interval between pollination and fertilization is only 3-4 weeks. This also means that the pollen tube completes its development in a rather short period.

The fusion of the male nucleus and the egg has not been observed. Figure 2 shows the two archegonia embedded in the female gametophyte. The one at the left is a fertilized egg in the prophase of the first division, and a dense cytoplasmic sheath is developed externally. The cell wall formation first takes place at the 4-nucleate stage, and figure 3 shows the same stage with walls completed. The proembryo occupies almost the entire space of the egg. This is in agreement with the finding of Coulter and Land (3) in *T. taxifolia,* but appears to differ from *T. nucifera* and *T. californica* as described by Buchholz (2).

The divisions are not always regular in subsequent stages and the cells in the proembryo are not always organized into distinct tiers. An 8-celled proembryo arranged in two tiers is shown at the right in figure 2. The later stages of proembryo are further shown in figs. 4-8. Figure 4 shows a 8-celled proembryo in which one cell above forms the open tier while the remaining cells below give rise to prosuspensor and embryo initials. The number of cells in the proembryo is variable, and 10, 12, 14 and 16 are the numbers commonly met with. Figure 5 shows a 10-celled proembryo in which the cells are not arranged in tiers. A 16-celled proembryo which consists of 4 cells in the open tier, 4 cells in the prosuspensor tier and 6 embryo initials, is shown in fig. 6. Figure 7 shows a 14-celled proembryo with the lower part of the pollen tube attached. In rare case the proembyo of forty cells has been also observed (fig. 8).

Differing from all the other Torreyas previously investigated by various authors (2, 3, 7, 8), the embryo of *T. grandis* passes no resting period but proceeds to develop and reaches maturity in the same year following fertilization; and so no *hibernal* embryo exists.

The next stages in development is the elongation of the prosuspensor with several embryo initials at its tip. The number of prosuspensor cells varies. Figure 12 shows an early embryo with six prominent prosuspensor cells and four embryo initials. This represents the normal type. The embryo in a little later stage, shown in fig. 13, has four prosuspensor cells and four embryo initials at their tip. It is of interest to note that one or several cells in the proembryo remaining behind may divide and give rise to embryos in the rosette region. These rosette cells are not recognizable until the prosuspensor cells become elongated. They are not derived from the prosuspensor cells

as suggested by Oinuma (5) since the total prosuspensor cells and embryo initials are fewer than the cells found in the proembryo. Figure 9 shows an embryo in which a single elongated prosuspensor cell is seen at the right side while six cells at the left are destined to become the rosette cells. This condition is further shown in fig. 10 and also in fig. 11. Figure 10 shows a proembryo with three deeply stained rosette cells on its upper region, and one of which is binucleate. There are four prosuspensor cells, one of which on the upper right of figure 10 is aborted, and two terminal cells which are vacuolated and without nuclei occur at the tip of the prosuspensor. A 12-celled proembryo which has three rosette cells remaining in the upper region of the 5-celled prosuspensor, is shown in fig. 11. Subsequent development of the rosette cells results in the formation of multicellular embryos as shown in fig. 18. Figure 17 shows the rosette cells not yet forming embryos at a later stage.

When the prosuspensor cells attain certain length the embryo initials at the tip begin to divide. The cell wall formed in the first division of the embryo initial is usually longitudinal. This agrees with the condition in *T. nucifera* as reported by Tahara (8). Each embryo initial at the prosuspensor tip develops into an independent embryo. Since several embryos usually develop from a single zygote the cleavage polyembryony is very extensive. Figure 14 shows an embryo system with five embryo units at the tip of the prosuspensor. Here the embryo unit on the right is in the 4-celled stage; below it is the one in the metaphase; a 2-celled embryo is on the left; and two undivided initials are dispersed among them. A later stage in development is shown in fig. 15 in which five embryos become separated from each other and the massive embryonal tubes are developed. No primary suspensor is formed.

The apical cell is recognizable from the sectioned preparation at the stage shown in fig. 16. There is no knowledge about the apical cell in other species. The prosuspensor cells may become embryonic (figs. 15 and 17) or develop into multicellular embryos as shown in figs. 19 and 20. Figure 21 shows a successful embryo still in cylindric form. A later stage with two equal cotyledons differentiated is shown in fig. 22. The secondary embryos derived from the rosette cells and the prosuspensor cells which have been pressed upwards by the elongating embryonal tubes and the massive enlargement of the successful embryo are on their way to disintegrate in the suspensor region.

DISCUSSION

Buchholz (2) states in his study of *Torreya* that the dense cytoplasmic sheath of the fertilized egg originates both from the male and the egg cytoplasm, but only a trace of male cytoplasm is included. However, in the present study no evidence could be found for such an occurrence in *Torreya grandis.* Before fertilization the egg is only surrounded by a layer of loose cytoplasm, while in the fertilized egg it is not only surrounded by this layer but also by a sheath of dense cytoplasm which envelopes it externally. This is in agreement with the opinion of Robertson (7) and Coulter and Land (3), that the distinct cytoplasmic sheath of the fertilized egg may originate from the male cytoplasm.

In *Torreya nucifera, T. californica* and *T. taxifolia* the proembryo becomes an arrested embryo through late autumn, winter and early spring. Buchholz (2) calls this winter stage the "hibernal embryo", which implies that it is slightly past the true

proembryo stage, and remains relatively inactive throughout late autumn, winter and early spring. In the case of *T. grandis* the hibernal embryo is not formed since the proembryo continues to develop without any resting period and the embryo complete its development in a single season. In our collection on May 26 we found 8, 10, 12, 14-celled proembryos as well as the proembryos with elongated prosuspensor cells, while on June 3 the embryo initials began to divide to form separated embryos at the tip of the prosuspensor. The development of independent embryos at the prosuspensor tip marks the beginning of the cleavage polyembryony. Furthermore, the presence of the embryos developing from rosette cells and the prosuspensor cells amply demonstrates the extensiveness of cleavage polyembryony in this species. This fact makes the genus *Torreya* exceptional in the Taxaceae.

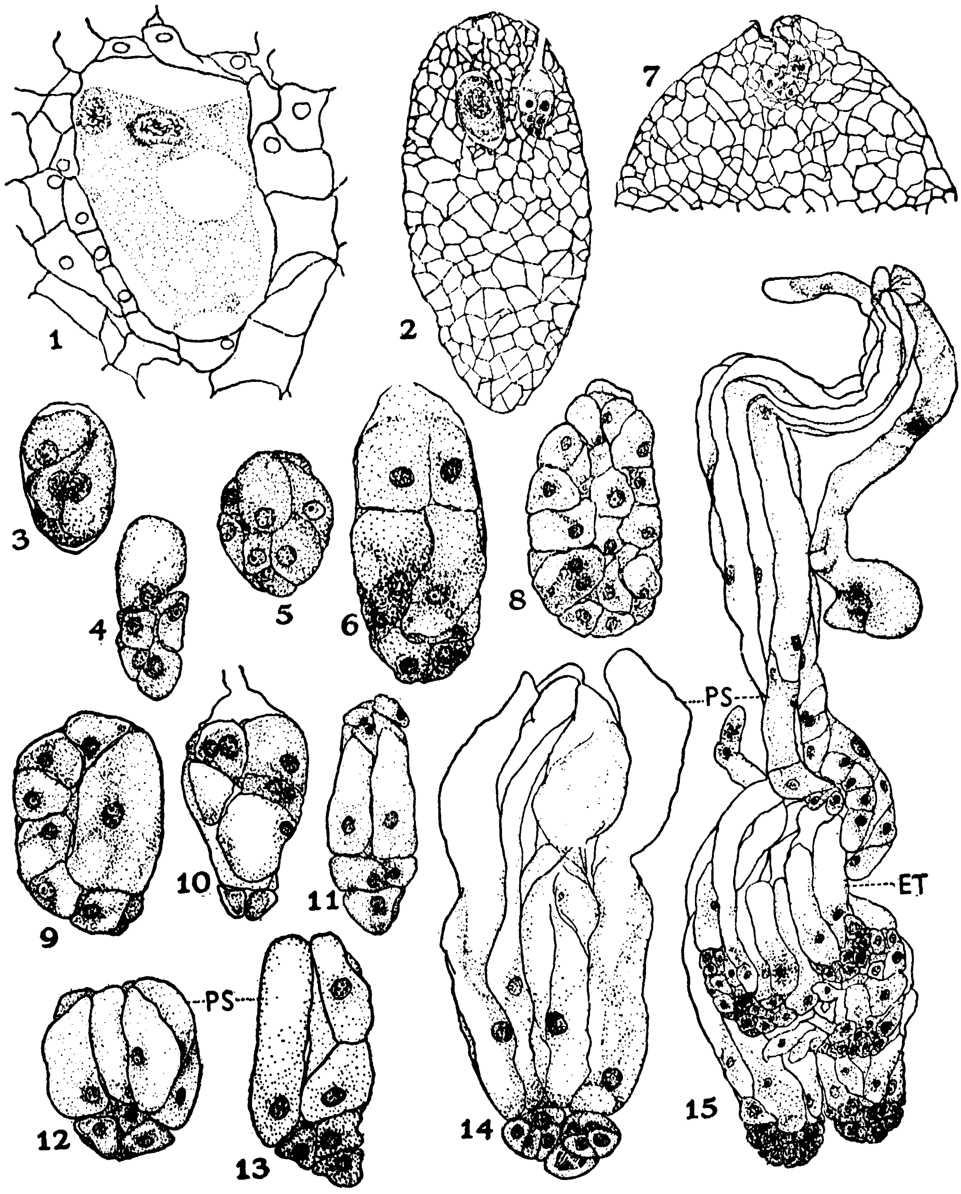
The presence of rosette embryo has been reported in *T. nucifera, T. californica,* and *T. taxifolia* (2, 3, 7, 8), but the origin of these rosette embryos still remains uncertain. In 1943, Oinuma (5) published a paper on the origin of rosette embryos in *Torreya.* He emphasized the fact that the nuclei of some slightly elongated prosuspensor cells are situated at the upper extremity of these cells (as he illustrated in his figure 1). He states that the rosette cells are cut off from these prosuspensor cells, but no dividing figures of these cells are shown in his drawings. Therefore, it is extremely doubtful if the rosette cells are really cut off from the prosuspensor cells. In the writer's opinion, the rosette cells are formed at an early stage in the proembryonal development. Since the cells of the proembryo are usually not organized into tiers, and only some of these cells may elongate to form a prosuspensor; some of the proembryonal cells may remain on the upper region of the prosuspensor. Owing to the slight elongating and enlarging of the prosuspensor cells, these remaining proembryonal cells are pressed upwards and give rise to the rosette cells. These observations were made on material illustrated in figures 9-11. At a later stage, subsequent division occurs in these rosette cells, which gives rise to the secondary embryos.

It seems *Torreya* is a specialized genus in the Taxaceae, and it shows within the family the peculiar modifications in its gametophytes and embryogeny to which reference has already been made. Buchholz (2) suggests that the three species stand in the following phylogenetic order: *T. nucifera, T. californica, T. taxifolia.* From the present study it is suggested that *T. grandis* shares the advanced morphological features of *T. taxifolia.* Some specialized characters which *T. grandis* has in common with *T. taxifolia* are as following: the rapid growth of the pollen tube shortening the period of development; the reduction in the number of archegonia; and the entire filling of the space of the egg by the cells of the proembryo. According to the present findings the phylogenetic position of *Torreya grandis* is in the following sequence: *T. nucifera, T. californica, T. grandis,* and *T. taxifolia.*

SUMMARY

The archegonium of *T. grandis* is commonly one in number. No jacket layer is observed in the surroundings of the archegonium. The ventral canal nucleus has been found. The cell wall in the proembryo begins to form at 4-nucleate stage. The proembryo fills the entire space of the egg. The cells are not always arranged in distinct

tiers and the tiers are not equal in the number of cells. The embryo completes its development in one season following fertilization. Rosette cells are formed in an early stage of the proembryonal development, and rosette embryo in *T. grandis* is very common. The first wall in the embryo cell is usually longitudinal. The prosuspensor cells may become embryonic or may develop into secondary embryos. The primary suspensor is absent. Apical cell has been found in the young multicellular embryo. Cleavage polyembryony is very extensive in *T. grandis*. Mature embryo is dicotyledonous.



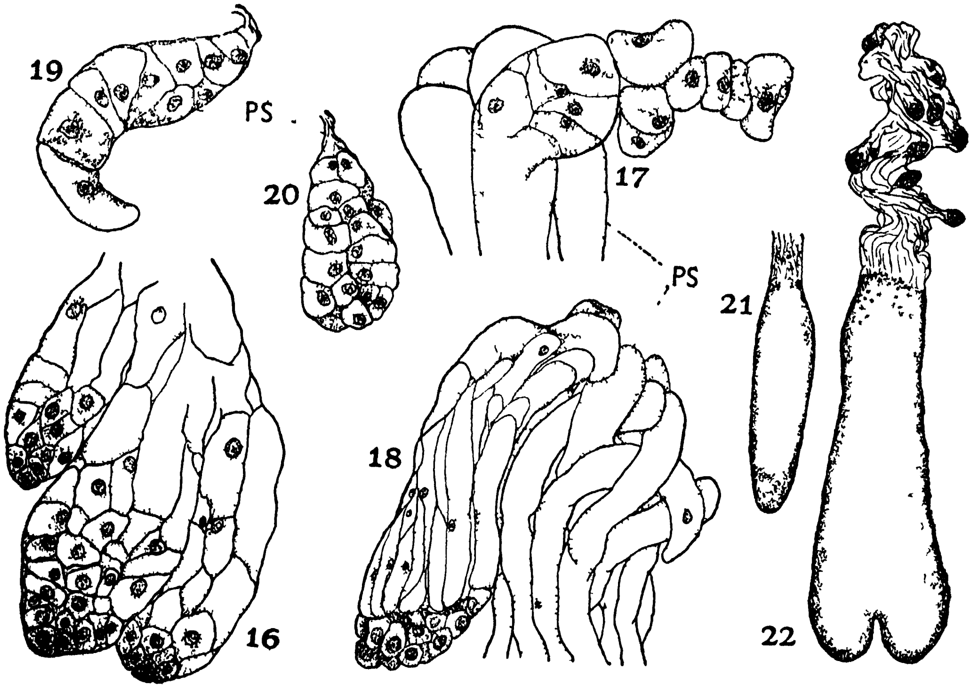


Fig 1, Ventral canal nucleus and egg nucleus x 380, May 4, 1947 —Fig 2, Section of female gametophyte containing a zygote and a proembryo x 84, May 4, 1947 —Fig 3, 4 celled proembryo, x 190, May 12, 1947 —Fig 4, 8 celled proembryo x 190, May 26, 1947 —Fig 5, 10 celled proembryo x 190, May 26, 1947 —Fig 5, 10 celled proembryo x 190, May 26, 1947 —Fig 6, 16 celled proembryo x 190, May 30, 1948 —Fig 7, Tip of female gametophyte containing a 14 celled proembryo x 84, May 26, 1947 —Fig 8, Proembryo of about 40 cells x 190, May 30, 1948 —Fig 9, 10 celled proembryo with a prosuspensor cell, beginning to elongate x 190, May 30, 1948 —Fig 10, 12 celled proembryo x 190, May 4, 1947 —Fig 11, Proembryo of 12 cells x 190, May 26, 1947 —Fig 12, 10 celled proembryo showing elongation of prosuspensor x 190, May 26, 1947 —Fig 13, Similar proembryo showing a prosuspensor is composed of two cells x 190, May 26, 1947 —Fig 14, An embryo system showing the development of the embryo initials x 190, June 3, 1948 —Fig 15, Slightly older embryo system x 84, June 20, 1948 —Fig 16, Section of three multicellular embryos x 190, June 27, 1948 —Fig 17, An abnormal rosette embryo at the end of the prosuspensor x 190, June 30, 1947 —Fig 18, A well-developed rosette embryo x 84, June 30, 1947 —Fig 19, 20, Embryos developed from prosuspensor x 190, June 30, 1947 —Fig 21, A later embryo, x 32, August 1, 1947 —Fig 22 Embryo with two cotyledens x 32, August 21, 1947, *ps*, prosuspensor, *et*, embryonal tube

The writer is deeply indebted to Dr. F. H. Wang for his direction and kind help during the progress of this study.

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THE EFFECT OF 2,4-DICHLOROPHENOXYACETIC ACID ON THE SPORE GERMINATION OF FUNGI

C. T. Wei & K. C. Ling

The use of growth-regulating substances in the control of noxious weeds has been explored for years and 2,4-dichlorophenoxyacetic acid (2,4-D) was found to be efficient and differential. It has already been used on a large scale. Its effect on the micro-organism is, however, little known. In the field of fungicides many aromatic compounds have been found superior to the popular mercurials. These facts led the writers to make the present study.

MATERIAL AND METHOD

The 2,4-D used in this experiment was furnished by Dr. Y. Wang of the Medical Institute of Academia Sinica, having a melting point of 137°C. 0.125% solution of the acid was prepared as the stock and kept in Pyrex-glass Erlenmeyer flask. For use it was diluted to such an extent that the final concentrations of 10 cc. lots were 1000, 300, 100, 30, 10, 3, and 1 p.p.m. Both the stock and the water for dilution were titrated to pH 3.9, the reason for which is to be given.

The water used was double distilled and kept in containers either of Pyrex or Jena glass. Necessary nutrients, dextrose or diluted orange juice, were often used to insure good germination. Although the orange juice is the complex to be controlled chemically, its use eliminated the difficulty of furnishing pure vitamins which are essential to the germination of some fungi (4).

The fungi used were all isolated from diseased materials collected either in Nanking or Shanghai. Though the same isolate was used each time, they were not single-spore cultures; but from the uniform results obtained, such precaution does not seem necessary. They were so selected as to represent different groups of fungi and different types of spores, namely: *Rhizopus nigricans* Ehr., *Mucor* sp., *Glomerella cingulata* (Atkin.) S. & S., *Colletotrichum phomoides* (Sacc.) Ches., *Aspergillus niger* van Tieghem, *Penicillium italicum* Weh., *Alternaria* sp., *Helminthosporium triseptatum, Phoma* sp., *Zythia* sp., and *Ustilago hordei* (Pers.) K. & S.

The cultures were maintained on potato dextrose agar except the spores of covered smut which were directly collected from the diseased head of barley. When the cultures

were at the prime of spore production, the spores were washed out by pouring redistilled water into the tube followed by vigorous shaking. The spore suspension thus obtained was then filtered through two layers of cheese cloth and divided between two 10 cc. centrifuge tubes. They were centrifuged at about 500 r.p.m. for a few seconds to remove heavier materials and then centrifuged at 3000 r.p.m. to precipitate the spores. Anything yet floating or suspended was discarded. Two additional washings of the spores with redistilled water were carried out to free the spores from any soluble substances which might be carried over from the medium. The spores were then suspended in redistilled water in a concentration ten times the final which gave about 80-120 spores per low power field.

When the dilutions of 2,4-D, nutrient solution, and spore suspension were made, with the aid of sterilized pipettes 8 cc. of the 2,4-D solution was introduced into each Pyrex Petri dish to which 1 cc. of nutrient solution and 1 cc. of spore suspension were added to make 10 cc. These transfers were done semi-aseptically so that bacterial contamination would not be serious enough to complicate the experiment during the period of germination. The dishes were incubated at 25°C. for 8 to 36 hours depending on the rate of germination of the fungus used. Too long a period of incubation will allow the formation of secondary conidia and confuse the result. The plate culture method was superior to the van Tieghem cell in insuring uniformity of environmental conditions and easy diffusion of oxygen and metabolic products. For each treatment three plate cultures were made.

After incubation the cultures were examined under the microscope. Four fields were sampled and 50 spores examined in each field, all at random. Averages were taken from these counts.

In a supplementary experiment with *Glomerella cingulata,* on the effect of the acid on growth, 40 cc. of 2,4-D solutions of different concentrations were placed in 150 cc. Erlenmeyer flasks. To each flask 5 cc. of Richard's solution, double strength, and 5 cc. of spore suspension were added to make 50 cc. The resulting solutions were essentially the same as those for the spore germination test with diluted Richard's solution (1-5) as nutrient. For each concentration of the acid, 5 flasks were used, and all of these were adjusted to pH 3.9. After its incubation for a forenight, the mycelial growth was removed, washed and its dry weight determined in Gouch crucibles with washed asbestos as the filtering mat.

PRELIMINARY CONSIDERATIONS

In order to standardize the treatments and conditions involved in this experiment, studies were made to find out the effect of centrifugation and conditions of the medium. Conidia of *Glomerella cingulata* were used as an indicator because it is one of the organisms commonly used by previous workers in bioassay and it is an easily obtained and delicate spore form. *Collectotrichum phomoides* was also used to check the results.

In the study of the effect of centrifugation, the spore suspension was subjected to 1000, 2000, and 3000 r.p.m. for 4 minutes once and 4 minutes twice, 2000 r.p.m. for 6 minutes once, and 1000 and 3000 r.p.m. for 8 and 12 minutes once. The spores were germinated in the previously described manner. The results showed that all except the last treatment, that is 3000 r.p.m. for 12 minutes, exerted no significant ill effect on

the spores. Three treatments of 3000 r.p.m. for 3 minutes were then regarded as the maximum in washing the spores.

The reaction of the medium in the first few tests was adjusted to the pH of redistilled water. Later it was found that 2,4-D was less active at this pH (Figs. 1 and 2). A parallel test was then designed to find out the effect of pH alone and the effect of 2,4-D at different pH values in sub-lethal concentration. Therefore the various pH of media were adjusted by adding different amount of N/100 HCl or N/50 NaOH. True to both organisms, the difference was found to be the greatest at pH 3.8 to 4.0, about 60% of germination in *Colletotricum phomoides*, about 40% in *Glomerella cingulata* (Figs. 1 and 2). In later experiments pH 3.9 was chosen as standard. It is, however, not the pH of the acid which is 2.9 in pure water. All pH values were determined with glass electrode.

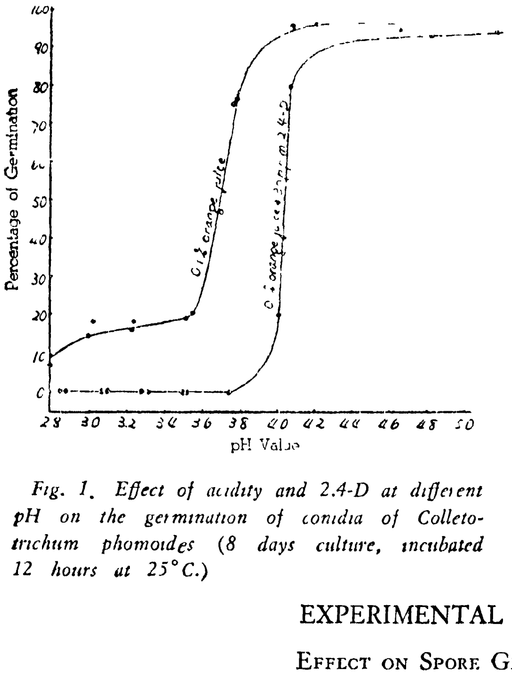

Fig. 1. Effect of acidity and 2.4-D at different pH on the germination of conidia of Colletotrichum phomoides (8 days culture, incubated 12 hours at 25°C.)

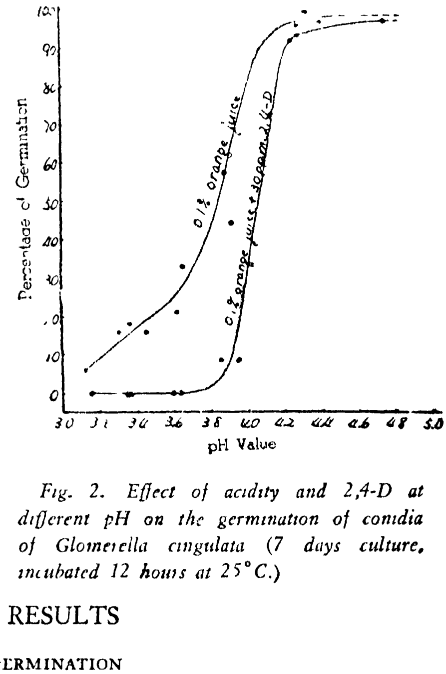

Fig. 2. Effect of acidity and 2,4-D at different pH on the germination of conidia of Glomerella cingulata (7 days culture, incubated 12 hours at 25°C.)

EXPERIMENTAL RESULTS

Effect on Spore Germination

For each organism, when two experiments yielded similar results, the data were considered fit; and whenever there was inconsistency, more tests were performed. This was seldom found necessary. The results are shown in Table 1.

In the earlier experiments emphasis was put on the finding of the concentrations at which spore germination will not take place. Different organisms vary in the ability of tolerance. *Aspergillus* was found to be most resistant, and considerable germination took place at 300 p.p.m., while the *Gloeosporium-Colletotrichum* group was most susceptible, and 100 p.p.m. invariably checked germination. None of the 11 organisms germinated at the concentrations of 300 and 1000 p.p.m.

The later experiments were so designed as to find out whether there is stimulating effect and where the prohibitive effect sets in. Such influence was expected to be most

TABLE 1. PERCENTAGE OF SPORE GERMINATION OF VARIOUS FUNGI IN DIFFERENT CONCENTRATIONS OF 2,4-DICHLOROPHENOXYACETIC ACID

Name of Organism	Expt. No.	Age of Culture	Nutrient Used	pH	Time for Incubation	Concentration of 2,4-D in p.p.m.					
						check	1	3	10	30	100
Rhizopus nigricans	I	6 days	1% j.	4.0	12 hours	93.3	94.8	93.5	90.8	89.3	83.3
	II	14 days	0.5% j.	3.9	12 hours	60.0	69.5	63.0	57.7	49.0	46.0
Mucor sp.	I	8 days	0.5% j.	3.9	12 hours	34.8	39.0	44.3	46.7	23.5	17.0
					24 hours	85.5	88.7	89.0	87.0	62.0	60.8
	II	14 days	0.5% j.	3.9	12 hours	41.0	54.5	59.5	73.0	44.0	23.5
					24 hours	88.0	88.0	89.0	88.0	77.0	60.0
Glomerella cingulata	I	7 days	1–5 R.	3.9	8 hours	89.7	90.2	90.2	88.2	51.3	0
	II	7 days	0.1% j.	3.9	12 hours	85.5	89.3	89.0	85.3	82.3	0
	III	7 days	0.1% j.	3.9	8 hours	44.3	55.0	47.5	37.3	0.5	0
					12 hours	84.5	86.0	85.3	79.7	21.0	0
					24 hours	—	—	—	90.5	81.7	0
	IV	5 days	0.1% j.	3.9	8 hours	59.0	58.5	62.7	41.0	3.5	0
					12 hours	90.5	89.7	90.7	88.3	23.0	0
					24 hours	—	—	—	—	86.7	0
Colletotrichum phomoides	I	8 days	0.1% j.	3.9	12 hours	75.3	87.0	86.5	75.5	26.8	0
	II	6 days	0.1% j.	3.9	10 hours	53.0	64.5	63.7	53.3	15.3	0
					14 hours	86.7	88.5	87.7	84.5	71.3	0
Aspergillus niger	I	6 days	0.5% j.	3.9	12 hours	91.0	92.5	91.3	90.0	88.0	54.7
					24 hours	94.0	94.5	94.0	92.5	93.0	92.0
	II	3 days	0.5% j.	3.9	12 hours	87.5	94.2	95.0	92.0	85.5	41.8
					24 hours	94.0	95.5	96.0	95.0	93.5	93.0
Penicillium italicum	I	4 days	1% j.	3.9	12 hours	96.5	97.2	97.2	97.2	95.5	86.7
	II	4 days	0.5% j.	3.9	12 hours	89.7	94.3	92.8	88.3	87.8	63.3
					24 hours	96.5	97.3	97.0	97.3	97.0	96.2
	III	7 days	0.5% j.	3.9	10 hours	74.3	81.5	79.5	78.3	66.5	20.5
					24 hours	94.5	95.3	95.3	95.3	95.0	94.3
Alternaria sp.	I	3 days	none	3.9	18 hours	43.2	45.2	54.2	42.8	42.0	0
					24 hours	75.5	76.2	78.0	74.8	75.0	0
	III	8 days	none	3.9	12 hours	62.3	68.3	78.5	58.0	41.2	0
					24 hours	80.3	81.5	81.3	80.5	79.8	0
Helminthosporium triseptatum	I	11 days	0.1% d.	3.9	12 hours	54.7	63.0	52.0	49.5	40.5	0
					24 hours	65.5	68.0	66.5	64.7	58.6	0
	II	9 days	0.1% j.	3.9	8 hours	57.3	66.5	65.0	50.5	48.7	0
					12 hours	93.0	94.0	94.0	88.5	59.5	0
Phoma sp.	I	15 days	0.5% j.	3.9	12 hours	88.0	90.0	91.0	89.5	89.3	68.5
	II	7 days	0.1% j.	3.9	12 hours	57.5	64.3	64.5	59.7	39.5	25.0
					24 hours	74.0	74.0	75.7	73.7	72.0	65.7
Zythia sp.	I	20 days	0.5% j.	3.9	12 hours	79.5	84.0	78.5	74.5	70.0	39.0
	II	15 days	0.5% j.	3.9	8 hours	46.3	62.5	54.5	44.8	41.0	23.5
					12 hours	81.7	85.2	82.5	79.5	76.5	45.0
Ustilago hordei	I	this year	0.5% j.	3.9	36 hours	57.3	60.5	60.3	51.5	36.0	0
	II	"	1.0% j.	3.9	24 hours	58.0	63.5	60.0	53.5	38.0	0
					36 hours	79.0	85.3	83.5	82.5	74.5	0

j. = fresh orange juice, R. = Richard's medium, d = dextrose (c.p).

apparent when the other factors for germination and non-germination of spores were controlled at a state which would allow about 50% of germination. By regulating the nutrient supplied and the time given for germination, this was accomplished. It was then found that low concentrations of acid often exert a slight, though definite, stimulative effect on germination, and the point of prohibition is rather marked. The latter is especially obvious after prolonged incubation. However the stimulation and the early inhibition by sub-lethal dosages are a function of time. It simply shortens or prolongs the time required for germination. When sufficient time is given, all viable spores will germinate, except in the rather high concentration of acid, and give a curve in the shape of an inverted "L". It can be shown by a graph based on representative data from *Glomerella cingulata* (Fig. 3).

The next problem to be solved was the type of action of the acid on the spores. A conidial suspension of *Glomerella cingulata* was added to the solutions of 2,4-D to make the final concentration of 0.01 and 0.1%. Some spores were sampled out at intervals to give the time of treatment 1, 2, 4, 6, 8, and 12 hours. They were washed and germinated in a medium containing 1% dextrose and M/100 sodium monobasic phosphate (NaH_2PO_4). The check showed 96% germination while spores from 0.01% acid gave 3.25, 7.03, 0.5, 5.14, 3.6, and 1.19% of germination in the respective durations of treatment and none of the spores from 0.1% acid germinated. The percentage did not change even after long period of incubation. And the period of treatment with 0.1% solution was shortened to 3 minutes. The killing apparently had already taken places.

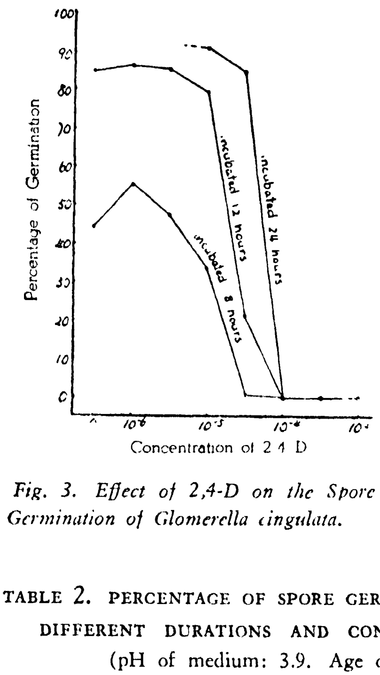

Fig. 3. Effect of 2,4-D on the Spore Germination of Glomerella cingulata.

A further test was conducted with the concentrations of acid changed to 1/10000, 1/8000, 1/6000, 1/4000, 1/2000, and 1/1000 mol to cover the critical range, and the time for treatment changed to 3, 10, 20, 40, and 60 minutes. The results are shown in Table 2.

TABLE 2. PERCENTAGE OF SPORE GERMINATION OF GLOMERELLA CINGULATA TREATED WITH DIFFERENT DURATIONS AND CONCENTRATIONS OF 2,4-DICHLOROPHENOXYACETIC ACID

(pH of medium: 3.9. Age of culture: 9 days. Incubated 10 hours at 25°C.)

Duration of treatment	Concentration of 2,4-D in Mol						
	check	1/10000	1/8000	1/6000	1/4000	1/2000	1/1000
3 minutes		72.4%	70.5%	63.0%	35.5%	2.5%	1.5%
10 minutes		57.0%	56.0%	52.5%	15.0%	0.5%	0.5%
20 minutes		54.5%	51.0%	46.0%	7.5%	0.0%	0.0%
40 minutes	76.8%	48.5%	46.5%	39.0%	6.5%	0.0%	0.0%
60 minutes		43.5%	43.0%	37.5%	4.5%	0.0%	0.0%
Throughout the experiment		41.5%	44.5%	38.0%	5.5%	0.0%	0.0%

From these results it seems that the effect of 2,4-D is not an inhibitive one. If the concentration is sufficiently high and the duration of treatment long enough to permit adequate infiltration of the acid into the cell, that effect will be lethal. When the concentration is too low or time is too short to kill the spores, all the originally viable ones will germinate, or the more resistant ones will germinate in sub lethal treatment. Inhibition apparently is not involved.

Effect on Growth

The effect of 2,4-D on the growth of *Glomerella cingulata* seems to be similar to the effect on spore germination except that stimulation is not apparent. This is rather to be expected because a prolonged treatment is unavoidable in growth studies and the stimulation is not detected in spore germination tests even when the time elapsed is longer than the critical period. The results were as Table 3.

TABLE 3. DRY WEIGHT OF MYCELLIUM OF GLOMERELLA CINGULATA GROWN IN 1-5 RICHARD'S MEDIUM CONTAINING DIFFERENT AMOUNTS OF 2,4-DICHLOROPHENOXYACETIC ACID IN MILLIGRAM

Expt. No.	Concentration of 2,4-D in p.p.m.							
	check	1	3	10	30	100	300	1000
1	126.3	125.9	99.0	135.4	137.9	0.0	0.0	0.0
2	154.7	143.7	110.6	120.8	101.3	0.0	0.0	0.0
3	140.3	107.5	121.4	130.7	115.9	0.0	0.0	0.0
4	128.8	113.3	143.2	112.3	116.7	0.0	0.0	0.0
5	104.4	151.5	123.3	111.7	111.6	0.0	0.0	0.0
Average	130.9	128.4	119.5	122.2	116.9	0.0	0.0	0.0

DISCUSSION

In our experiments, the reaction of these fungi to 2,4-D is in general agreement with the reactions of organisms to many hormones, minor elements, or toxic substances. In minute quantities the growth is stimulated, while in larger dosages it is inhibited. Although different organisms vary in their resistance to 2,4-D, they yield the same type of curve. It is quite in contrast with the results obtained by van Overbeek and Vólex (7) with tropical weeds. Our knowledge of both phenomena is too meager to over any explanation for the difference.

An early work by Boysen-Jensen (1) showed that Rhizopin or indol-3-acetic acid, even in rather minute quantities, retards the growth of *Aspergillus* in a glucose-nitrate citric acid solution. Nielsen and Hartelius (6) and Bünning (3) considered the hormone to have no furthering effect on the growth of this fungus. A more recent paper by Stevenson and Mitchell (8) reported the high tolerance of *Fusarium* and *Penicillium* to 2,4-D and its sodium salt. Even a concentration of 0.08% did not materially prevent growth. However, the medium they used was titrated to pH 6 and 7 at which 2,4-D was found by the writers to be far less active (Figs. 1 and 2). This difference is probably sufficient to account for the discrepencies in results.

As found in higher plants, high concentration of hormone formed at the tip inhibits the development of the lateral buds and elongation of the root tips. Such effect was proved to be inhibitive and growth will resume as soon as the entity is removed, while in the case of 2,4-D the effect is definitely lethal, either in higher plants or in fungi. Even in lower concentrations killing may be partial, but inhibition

is not detected. Although it permits a good portion of spores to germinate, the ungerminated ones will remain so after the acid is removed and nutrients, which will support germination of viable spores, are freely supplied. The mechanism involved seems to be fundamentally different from hormones.

As the selective effect of 2,4-D on higher plants is not yet explained it is equally difficult to assign the behavior of fungi to any particular life processes. Neither the explanation of Lou and Hsueh (5) that 2,4-D inhibits aerobic respiration or Brown's (2) finding of accelerated respiration of bean under the influence of 2-4-D will offer an explanation to the almost instant killing of spores by the acid. Sweeney's report (9) on the effect of auxin on protoplasmic streaming in root hair of *Avena* gave a more plausible hint that protoplasmic activity is directly affected. However the real mechanism remains obscure.

SUMMARY

1. Effect of 2,4-D on several phytopathogenic fungi was studied. Potency of the compound was found highest at the acid range. Above pH 4.0 the activity rapidly decreases.

2. Fungi differ in resistance to 2,4-D, but they yield the same type of curve if the percentage of spore germination is plotted against the concentration. Germination the percentage of spore germination is plotted against the concentration. Germination of spores of the *Gloeosporium-Colletotrichum* type is entirely prevented by 100 p.p.m. at pH 3.9 while *Aspergillus* can tolerate up to 300 p.p.m.

3. In high dilution the acid may exert a stimulative effect, but it only shortens the time required for germination without finally increasing the precentage.

4. The action of concentrated 2,4-D on spores is fungicidal rather than fungistatic and the action is almost instant. The time required is probably a function of penetration and accumulation.

5. In *Glomerella cingulata,* 2,4-D exerts a similar effect on the growth of mycelium and on the germination of spores.

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CHEMICAL STIMULATION IN POLLEN GERMINATION AND POLLEN TUBE GROWTH

TSUNG-CHEN HUANG

In a previous paper, (21) Loo and Huang demonstrates definitely the effect of manganese sulphate, auxin, and colchicine on the germination and growth of pollen. The present paper is a continuation of the previous work

MATERIALS AND METHODS

The materials used in the present experiments were (1) the pollen of peach (*Prunus persica*), (2) apricot (Prunus armeniaca), and (3) pine (Pinus massoniana), all obtained from the Agricultural Experiment Station of the Chekiang University at Meitan, Kweichow, in the spring of the year 1944. At Meitan the upricot blossoms earlier than the peach and the pine still later. Pollen of cherry, plum, pear, onion, lily, gingko were also used; but as the results obtained from them were similar to the above mentioned plants, it is needless to repeat. The chemicals employed were micro-elements, vitamins, auxins, amino acids, organic acids, colchicine, etc.

The room temperature under which the experiments were carried out differs according to the time the materials were obtained: For example, with apricot, it was above 14°C; with peach, above 15°C; with pine, above 18°C. When the plant was in its full blossom, the flower branches were cut about seven o'clock on sunny mornings, put in vials, and brought directly into the laboratory. Then the pollen was dealt with immediately. If it happened to be rainy or bad weather, the flowers collected on the previous day might be used. The pollen grains which were best fit for our purpose were those obtained from the same flower at the rupture of the anthers and before the dispersal of the pollen grains, for the percentage of growth and germination were the greatest with these materials.

Hanging drop method is generally employed; when the pollens of peach and apricot were used, however, the method of Addicot (1), was adopted, using the 90 x 10 mm. Petri dishes instead of concave slides.

The experiments with the apricot pollen began at 8 a.m. The observation began at nine. The length of pollen tubes were measured once an hour. So every series of experiments was completed at 5 p.m. on the same day.

In the case of the peach the experiments were started at 7 a.m. and ended at 5 p.m., observation being made once an hour, too. As for the pollen of pines, thick and hard cover glasses were used. On the glass the medium was placed in the form of a hanging drop, into which the pollen grains were dispersed with the help of a platinum loop. The cover glass was then mounted on a concave slide and sealed with paraffin to prevent the evaporation of the hanging drops. The concave slides were then kept in an incubator till six of the next afternoon, when it was examined for the percentage of germination and elongation. The measurement was repeated once every twelve hours till the tube elongated no more. Smith (27) determined the percentage of germination of *Pinus austriaca* at six hours after experiments at the temperature from 25°C to 27°C. In the present work, measurements and counting were began at at thirty-four hours after the experiment, because the pollen germinated very slowly

at lower temperature. The growth curve of peach, apricot, and pine pollen tubes under control series assumed an S-shape, as if controlled by monomolecular catalytic reaction.

In each treatment with a single kind of test substance, four drops had to be observed each drop containing about 200 pollen grains. Ten pollen tubes were chosen at random for the measurement of the average length of the tubes. As the basic medium, which also served as the control, 0.55 M of glucose solution was used for apricot and peach pollen, and 0.3 M of sucrose solution was used for pine pollen. To the basic medium the following series of chemicals, about forty in number: 1. micro-elements, 2. vitamins, 2. fatty acids, 4. hydroxy acids, 5. dibasic organic acids, 6. amino acids, 7. indole derivatives, 8. miscellaneous (containing colchicine, purines, and synthetic growth substances), were added, respectively, making a concentration of 10^{-5} M.

All the apparatus and culture media used were thoroughly sterilized before use. The chemicals used were from E. Merck and Kahlbaum except indole derivatives, which had been purified by the Department of Chemistry of the Chekiang University, and auxins and colchicine which were obtained from Kodak (c.p.). Redistilled water alone was used.

RESULTS AND DISCUSSION

Though only the final percentage of germination and measurement of tube growth interval are shown in the following tables, the growth curves of peach pollen are given in the text to show the general feature of growth and the effect of chemicals upon it.

MICRO-ELEMENT SERIES. In these experiments four chemicals were used, namely, $MnSO_4$, $ZnSO_4$, $CuSO_4$, and H_3BO_3. The results may be seen from tables 1, 2, and 3. It is obvious that 10^{-5}M $CuSO_4$ had a toxic effect on the germination of pollen and the growth of pollen tubes. Most of the tubes bursted and some of them emerged from both of the germspores. Berg (4) and Bobko and Zerling (6), however, found that a trace of copper in the culture media promoted pollen of certain plants to germinate. It might be that the concentration used by the writer was too strong, as copper is in itself a toxic substance. Figure 1 shows that B, even Zn and Mn, exert favorable effect, B being better than Mn, and Mn better than Zn. Schmucker (26) observed that B induced the growth of pollen. Bobko and Zerling (6), Blaka and Schmidt (5), Cooper (12), Vasil'ev (31), Addicott (1) made the same reports. And the fact that Mn and Zn were good for growth and germination was mentioned by Bobko and Zerling (6), Cooper (12), Loo and Huang (21) and Loo (20). In the writer's experiments, the pollen tubes elongated constantly, and their shape was slender and straight. Niethammer (24) in his experiment with certain heavy metals of optimum concentration found the same stimulating effect. As regards to the role of minerals in pollen growth, Lidforss (19) Tokugawa (30), Brink (7) also considered them as being toxic, and Miyoshi (22), as having no effect on polken growth. Brink (10), however, reported that if two salts, such as Mg and Ca, were present in the same medium, they might react with K or Na so as to result in antagonism. He still observed that a yeast preparation with ash might help towards the growth of pollen tubes, and Paton (25) mentioned that media containing 0.5% $MgSO_4$, 0.1% KCL, 0.01% $FeSO_4$ and 0.2% agar had the same good effect. The results of the present work show that micro-elements, except copper, accelerate pollen germination and pollen tube growth.

VITAMIN SERIES. The vitamins used, such as ascorbic acid, thiamin hydrochloride, inositol and nicotinic acid are all water soluble chemicals. From tables 1, 2, 3, and figure 2, we found that the above mentioned vitamins all accelerated pollen germination and promoted tube growth, though they exerted less effect than micro-elements. Brink (8) pointed out that chemically pure sugar solution with a proper amount of sterile yeast extract preparation brought out the same response, because yeast extract consists of pyridoxin, thiamin, lactoflavin, nicotinic acid, etc. Dandliker, Cooper and Traub (13), Cooper (12), Addicott (1) and Wang (32), too, reported that vitamins were good for the germination of pollen grains. Smith (28), however, regarded thiamin as being of no influence on pollen growth, and even of depressing effect, if it was of too strong

TABLE 1. EFFECTS OF MICRO-ELEMENTS, VITAMINS, FATTY ACIDS, HYDROXY ACIDS, DIBASIC ACIDS, AMINO ACIDS, AUXINS, INDOLE DERIVATIVES, PURINES AND COLCHICINE ON POLLEN GERMINATION AND POLLEN-TUBE GROWTH OF APRICOT
BASIC MEDIUM: 0.55 M GLUCOSE. TEMPERATURE: 14-15°C.

Treatment	Counted grains	Germination Percentage	Pollen tube length in mm. (Final)
Control	804	70.4	1.109
$MnSO_4$	418	90.1	2.441
$ZnSO_4$	403	85.9	2.114
$CuSO_4$	415	39.5	0.813
H_3BO_3	388	91.8	2.507
Control	439	70.1	1.182
Ascorbic acid	386	80.1	1.590
Thiamin	379	76.5	1.388
Nicotinic acid	356	77.4	1.329
Inositol	371	74.9	1.440
Control	448	64.2	1.288
Formic acid	528	40.9	0.808
Acetic acid	456	50.8	0.993
Propionic acid	536	47.7	1.020
Butyric acid	481	60.8	1.103
Valeric acid	507	65.1	1.201
Control	250	60.0	1.202
Lactic acid	376	54.2	1.049
Tartaric acid	384	77.2	1.220
Glycollic acid	361	78.5	1.404
Malic acid	388	76.3	1.498
Citric acid	383	78.9	1.507
Control	244	67.2	1.240
Oxalic acid	318	67.9	1.177
Succinic acid	385	84.5	1.492
Fumaric acid	390	85.1	1.480
Maleic acid	444	77.2	1.244
Malonic acid	389	63.6	1.218

Treatment	Counted grains	Germination Percentage	Pollen tube length in mm (Final)
Control	493	65.1	1.023
Glycine	619	62.7	1.130
Alanine	698	62.1	1.021
Leucine	214	69.9	1.024
Aspartic accid	431	74.6	1.416
Glutamic acid	309	79.1	1.445
Arginine	341	56.8	0.990
Tyrosine	306	68.5	1.104
Control	701	64.7	1.020
Indole	695	42.8	0.728
Skatole	671	44.5	0.794
S.M.A.	618	41.7	0.842
I.A.A.	395	70.1	1.021
I.P.A.	402	69.2	1.010
Tryptophane	403	78.8	1.341
Control	452	68.3	1.132
Uric acid	444	65.9	0.967
Guanine	398	74.1	1.303
N.A.A.	425	76.2	1.118
P.A.A.	412	78.2	1.141
Cinnamic acid	324	72.1	1.184
Colchicine	401	78.1	1.102

S.M.A.: Omega-Skatolyl-malonic acid. I.A.A.: Indole-3-acetic acid. I.P.A.: Indole-3-propionic acid, P.A.A.: Phenyl-acetic acid. N.A.A.: beta-Naphthoxy acetic acid. Cinnamic acid: Cis-cinnamic acid Thiamin: Thiamin-hydrochlorite. Glutamic acid: Glutamic acid-hydrochloride.

a concentration. But the weakest concentration used by Smith was 1/100,000 ,which may be too strong for pollen growth. Though vitamins are chemically different from micro-elements, but, being organic catalysers, they ought to accelerate pollen growth as micro-elements do.

FATTY ACID SERIES. Lidforss (19), Cooper (12) found that the presence of formic acid, acetic acid favoured pollen germination. But according to the writer's experiments, formic acid was toxic, and acetic acid depressed the growth. Among fatty acids, only those of high carbon numbers were less toxic. (See tables 1, 2, 3 and figure 3).

HYDROXY ACID SERIES. According to some authors (23, 19, 17, 24, 1.), organic acids stimulate the growth of pollen. The writer using lactic, tartaric, glycollic, malic and citric acids as test substances, also found that except lactic acid, the other four acids all promoted pollen growth (See tables 1, 2, and 3).

TABLE 2. EFFECTS OF MICRO-ELEMENTS, VITAMINS, FATTY ACIDS, HYDROXY ACIDS, DIBASIC ACIDS, AMINO ACIDS, AUXINS, INDOLE DERIVATIVES, PURINES AND COLCHICINE ON POLLEN GERMINATION AND POLLEN-TUBE GROWTH OF PEACH
BASIC MEDIUM: 0.55 M GLUCOSE. TEMPERATURE: 15-16°C.

Treatment	Counted grains	Germination Percentage	Pollen tube length in mm (Final)
Control	398	68.5	1.375
$MnSO_4$	445	87.6	1.830
$ZnSO_4$	512	90.9	1.766
$CuSO_4$	527	46.5	0.980
H_3BO_3	384	95.8	2.076
Control	440	70.1	1.405
Ascorbic acid	518	82.8	1.592
Thiamin	512	78.5	1.525
Nicotinic acid	396	74.6	1.500
Inositol	424	78.0	1.510
Control	554	67.8	1.430
Formic acid	626	43.8	1.094
Acetic Acid	530	54.5	1.224
Propionic acid	478	58.6	1.321
Butyric acid	549	69.7	1.372
Valeric acid	435	68.0	1.442
Control	693	64.3	1.428
Lactic acid	412	59.8	1.305
Glycollic acid	445	66.8	1.466
Tartaric acid	550	72.4	1.477
Malic ccid	515	78.4	1.472
Citric acid	625	81.5	1.557
Control	388	62.6	1.428
Oxalic acid	440	67.0	1.446
Succinic acid	536	73.7	1.516
Fumaric acid	580	65.5	1.446
Maleic acid	523	44.0	1.435
Malonic acid	414	63.6	1.422
Control	563	64.2	1.398
Glycine	626	65.8	1.400
Alanine	574	64.9	1.380
Leucine	658	63.8	1.405
Aspartic acid	480	76.6	1.508
Glutamic acid	404	79.8	1.575
Arginine	585	58.0	1.325
Tyrosine	602	66.3	1.382
Control	394	69.1	1.328
Indole	432	48.8	0.671
Skatole	466	50.2	0.766
S.M.A.	428	49.8	1.134
I.A.A.	384	76.5	1.312
I.P.A.	347	74.8	1.238
Tryptophane	472	72.6	1.394
Control	502	64.6	1.438
Uric acid	514	58.5	1.334
Guamine	605	69.0	1.470
N.A.A.	485	75.7	1.382
P.A.A.	472	74.2	1.420
Cinnamic acid	448	73.8	1.464
Colchicine	513	60.7	1.168

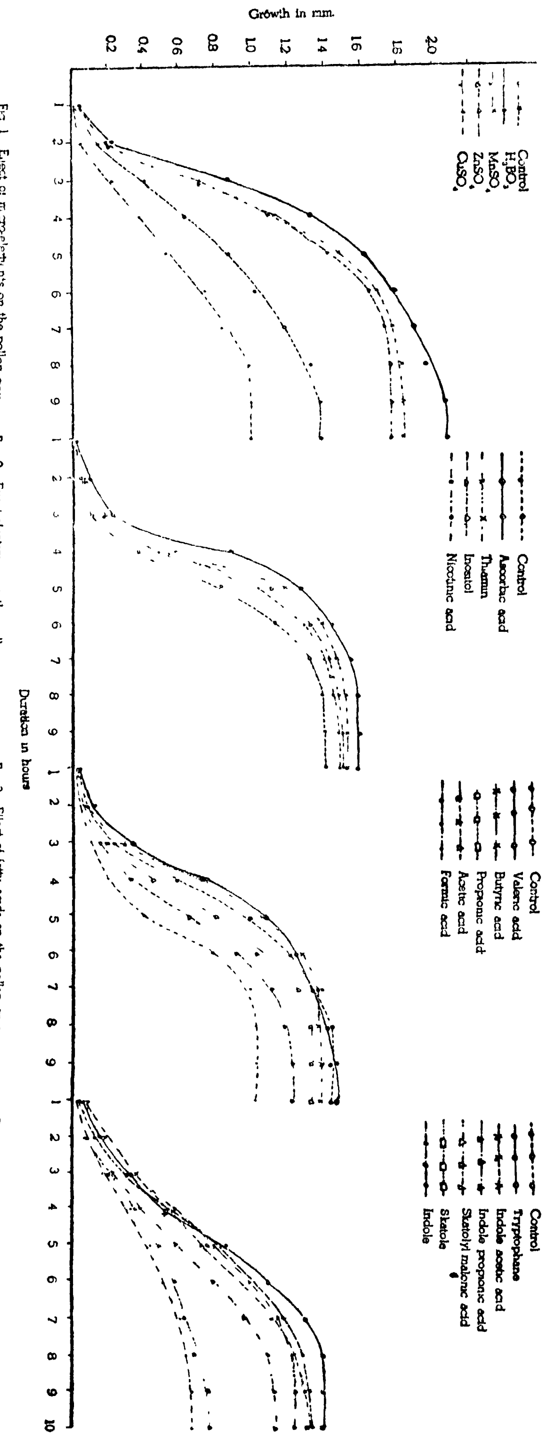

Fig. 1 Effect of microelements on the pollen germination and pollen tube growth of peach

Fig. 2 Effect of vitamins on the pollen germination and pollen tube growth of peach

Fig. 3 Effect of fatty acids on the pollen germination and pollen tube growth of peach

Fig. 4 Effect of indole derivatives on the pollen germination and pollen-tube growth of peach

DIBASIC ORGANIC ACID SERIES. Lidforss (19), Brink (11), and Niethammer (24) found that succinic acid and oxalic acid promoted the growth of pollen. From tables 1, 2, and 3, it is also evident that succinic acid and fumaric acid, which are commonly found in plants, accelerate pollen germination and pollen tube growth, while the maleic acid, the isomer of fumaric acid, had no influence on them. The effect of oxalic acid and malonic acid was not appreciable.

AMINO ACID SERIES. Miyoshi (22), Lidforss (19), Tokugawa (30), Knight (18), Brink (8), Cooper (12), Addicott (1), Wang (32) observed that amino acids or peptone promoted the germination of pollen. But according to the writer's experiments, except aspartic and glutamic acid, the effect of glycine, alanine, arginine, leucine, tyrocine was negligibile (See tables 1, 2 and 3.).

INDOLE-DERIVATIVES SERIES. The chemicals used in this series consisted of indole, skatole, tryptophane, indole-3-acetic acid, indole-3-propionic acid, and ω-skatolyl-malonic acid. Glove (16) pointed out that the effect of skatole was something like that of auxin, and Stewart (29) was of the same opinion as regard to tryptophane. Davis, Atkins, and Hudson (14) reported ω skatolyl-malonic acide, skatole, indole-acetic, indole-

TABLE 3. EFFECTS OF MICRO-ELEMENTS, VITAMINS, FATTY ACIDS, HYDROXY ACIDS, DIBASIC ACIDS, AMINO ACIDS, AUXINS, INDOLE DERIVATIVES, PURINES AND COLCHICINE ON POLLEN GERMINATION AND POLLEN-TUBE GROWTH OF PINE. BASIC MEDIUM: 0.3 M SUCROSE. TEMPERATURE: 18-21°C.

Treatment	Counted grains	Germination Percentage	Pollen tube length in mm. (Final)	Treatment	Counted grains	Germination Percentage	Pollen tube length in mm. (Final)
Control	892	31.0	0.608	Control	892	31.0	0.608
$MnSO_4$	914	59.9	0.894	Glycerine	720	32.4	0.602
$ZnSO_4$	1224	53.8	0.837	Alanine	983	32.8	0.601
$CuSO_4$	674	21.8	0.462	Leucine	1052	30.5	0.592
H_3BO_3	984	63.2	0.990	Aspartic acid	725	37.1	0.624
Thiamin	560	54.6	0.704	Glutamic acid	880	41.2	0.630
Ascorbic acid	878	53.2	0.776	Arginine	588	30.4	0.581
Nicotinic acid	770	54.0	0.721	Tyrosine	1280	31.5	0.601
Inositol	863	51.5	0.730	Control	725	33.1	0.612
Control	1054	32.8	0.604	Indole	705	19.8	0.360
Formic acid	874	20.1	0.329	Skatole	645	24.7	0.376
Acetic acid	885	28.2	0.567	S.M.A.	923	25.4	0.465
Propionic acid	923	28.8	0.612	I.A.A.	954	36.5	0.584
Butyric acid	1145	29.4	0.571	I.P.A.	748	37.7	0.594
Valeric acid	1074	30.1	0.574	Tryptophane	642	40.0	0.632
Lactic acid	674	18.9	0.547	Uric acid	820	25.6	0.432
Tartaric acid	1051	38.4	0.610	Guanine	658	37.2	0.624
Glycollic	774	42.5	0.668	N.A.A.	1075	37.4	0.604
Malic acid	1125	50.2	0.674	P.A.A.	735	40.2	0.601
Citric acid	1214	53.8	0.672	Cinnamic acid	679	32.0	0.607
Oxalic acid	1035	30.5	0.590	Colchicine	587	26.5	0.437
Succinic acid	794	44.6	0.620				
Fumaric acid	872	43.5	0.629				
Maleic acid	872	33.0	0.608				
Malonic acid	1210	34.8	0.590				

propionic acids inhibited seed germination. The reponse of auxin on the germination of pollen grains has been studied by Smith (27, 28), Cooper (12). Tables 1, 2, 3 and figure 4 reveal that the effect of indole-3-acetic acid and indole-3-propionic acid on the germination of pollen grains and early growth of pollen tubes was stimulative, though their effect became less and less as time went on, and the form of the tube grown in these media was abnormal. As reported by many authors (28, 1, 32, 21), auxin was toxic, when its concentration was a little too strong. The present results show that it is just the case. The effect of tryptophane was favorable, but that of indole, skatole, and ω-skatolyl-malonic acid was toxic.

MISCELLANEOUS SERIES. In this series several growth substances (colchicine, phenyl acetic acid, β-naphthoxy acid, cis-cinnamic acid), uric acid and guanine were used. Concerning colchicine, Eigsti (15) Smith (28), Wang (32) reported that it exerted harmful effect upon pollen, a fact contradictory to that found by Loo and Huang (21). In the present work, the writer using a stronger concentration of 10^{-5}M. found that colchicine at first stimulated the growth of pollen but inhibited it at last, especially in the case of pine. In the case of apricot, colchicine showed beneficial effect. Uric acid proved to be toxic, while the effect of guanine was a little better. The three other synthetic growth substances at first promoted the pollen tube growth but at last depressed it.

To summarize the results of the above mentioned experiments, the chemicals used may be divided into three groups according to their effects upon pollen germination and pollen tube growth as shown in the following:

BENEFICIAL	INDIFFERENT	HARMFUL
$MnSO_4$	Propionic acid	$CuSO_4$
$ZnSO_4$	Butyric acid	Formic acid
H_3BO_3	Valeric acid	Acetic acid
Thiamin	Lactic acid	Indole
Ascorbic acid	Oxalic acid	Skatole
Nicotinic acid	Maleic acid	S. M. A.
Inositol	Malonic acid	Uric acid
Tartaric acid	Glycine	
Glycollic acid	Alanine	
Malic acid	Leucine	
Citric acid	Arginine	
Fumaric acid	Tyrosine	
Succinic acid	Tryptophane	
Aspartic acid	I.A.A.	
Glutamic acid	I.P.A.	
	N.A.A.	
	P.A.A.	
	Cinnamic acid	
	Colchicine	
	Guanine	

Except the third group which contains toxic substances, the effect of chemicals of the other two groups may be pondered briefly as follows:

Among the members of the first group which may be called beneficial, are micro-elements (except Cu), vitamins, tartaric, glycollic, malic, citric, fumaric, succinic, aspartic, glutamic acids. Micro-elements and vitamins are well known catalysts. They may

accelerate the enzymatic action which is involved in the metabolic changes during germination and growth. It is, therefore, not unexpectable that their presence stimulates the process of germination and tube elongation of pollen. The tartaric, glycollic, malic, citric, fumaric, succinic acids may play a part in the respiration as argued by St. Györgyi and Krebs. The part played by aspartic and glutamic acid can not yet be explained. Possibly they have something to do with the synthesis of protein.

The second group consists of many acids, colchicine and guanine. They were neither markedly beneficial nor harmful to pollen growth. That is to say they have nothing to do with the mobilization of reserve material in the pollen grain and the resynthesis of cell materials. But in low concentration they may cause stimulation, since pollen germination is general accelerated in acid medium as reported by many authors. This statement holds good especially to indole-acetic, indole-propionic, naphthoxy acetic, phenyl acetic acids—the so-called auxins.

SUMMARY

Studies of pollen germination and pollen tube growth in *Prunus armeniaca, Prunus persica* and *Pinus massoniana,* were designed to show the effects of the additiion of micro-elements, vitamins, fatty acids, hydroxy acids, dibasic organic acids, amino acids, auxins, indole-derivatives, purines and colchicine to culture medium; and hanging drop technique was employed.

The micro-elements excepting $CuSO_4$ were markedly favorable for pollen germination and pollen tube growth. The vitamins, some amino acids and other organic acids, could moderately stimulate both germination and tube elongation. Evidence of favorable effect by addition of auxins were not found. But the lower concentration of auxins were less effective than micro-elements and vitamins in accelerating pollen germination and in promoting pollen tube growth. A higher concentration was definitely growth inhibiting as some anaesthetics or toxins. Colchicine in higher concentration had depression effect on both germination and tube elongation but lower concentration stimulated the growth of pollen.

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ANNOUNCEMENT

Owing to the recently planned field work which necessitates a long period of my absence from office, and in order to complete the present volume, the September and December numbers of this Bulletin for the current year have to be published in advance of the regular date of issue. It is my hope that a new editor will be appointed to take charge of the ensuing volumes.

S. C. Teng

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ERRATA

Page	Line	For	Read
10	Fig 13 inverted.		
15	2nd from bottom,	jaqes	Jaques
10	11th „ „	*alphina*	*alpina*
20	21st	qucad.	quoad
60	20th from bottom,	Arthrodesum	Arthrodesmus
85	7	Figure 9, figure 10	(9), and (10),
„	15	figures 21, 22,	(21, 22)

INTERSPECIFIC CROSSES IN SETARIA
III. CHROMOSOMAL VARIATION IN S. ITALO-FABERII

C. A. Hsia

INTRODUCTION

In crossing species of *Setaria* for the elucidation of their phylogenetic relationships, Li, et al. (2) succeeded in crossing a green foxtail-like plant in the G_2 generation of *S. italica* (L.) Beauv. (2n = 18) X *S. viridis* L. (2n = 18) as the female plant and *S. faberii* Herrn. (2n = 36) as the male plant. Morphologically, the ear-head of this tri-species hybrid is about as long and wide as that of the male parent *S. faberii*, but it is decidedly longer and wider than that of the female plant. Cytologically, there is a constant association of nine bivalents and nine univalents in the MI suggesting that *S. italica* and *S. viridis* have genom A, and *Setaria faberii* has genom A and B. By treating the young ear-heads of this hybrid plant with different strengths of colchicine solution, "amphidiploid" plants were obtained. They are characterized by having stiff and thick foliage with a dark green color. They are decidedly larger plants than either one of the two parents with large ear-head both in length and width and large seeds. This "amphidiploid" thus produced was given the name *S. italo-faberii* (3) for convenience. Cytologically, sometimes, 27 bivalents are encountered, but more often, some multivalents are found (unpublished data). This "amphidiploid" has been cultivated for seven generations up to the present with the intention to obtain a true breeding strain with 27 bivalents. In 1947, the progenies of this "amphidiploid" were given to me by Dr. Li for detailed study. The findings are reported in this paper.

EXPERIMENTAL RESULTS

1. Variation In The Number Of Chromosomes. In the original "amphidiploid", namely the *S. italo-faberii*, the somatic chromosome number is 54, however, plants with various number of chromosomes were obtained as the experiment progressed. Since each generation was cultured without apparent selection, the chromosome numbers of the plants in the G_6 generation in Fig. 13 would represent a random sample of the population.

Among the 52 plants examined in 1947, 31 plants were found to have 54 somatic chromosomes. These 31 plants with 54 chromosomes represent the modal class of the normal curve (Fig. 13), and the spread is represented by plants with 51 to 58 chromosomes. In 1948, the seeds for the G_7 population were chosen deliberately from plants mostly having somatic chromosomes other than 54. As a result, plants with 54 somatic chromosomes are still the modal class in a population of 38 plants, but the spread widens greatly including plants with 49 to 62 somatic chromosomes (Fig. 13). The possible explanation for this variation in the number of chromosomes will be discussed later.

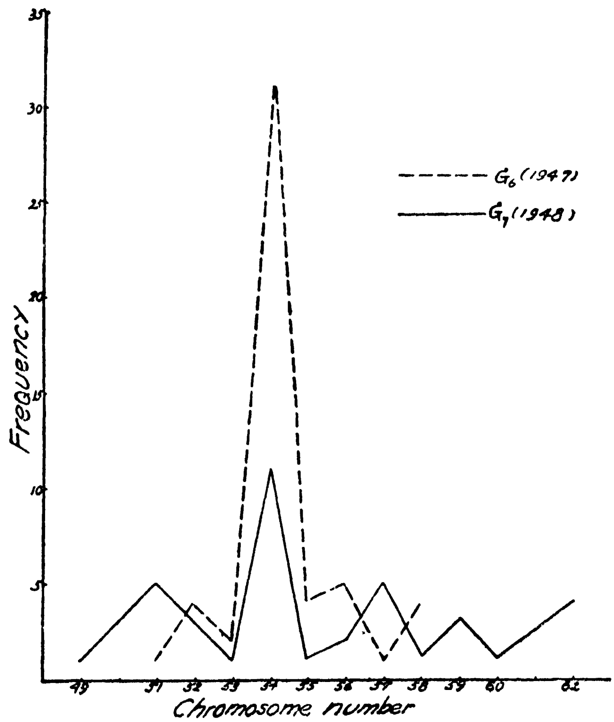

Fig. 13. Frequency distribution of plants with varying number of chromosomes in G_6 and G_7.

2. Chromosomal Constitution Of Plants In The G_7 Generation. Generally, plants of this "amphidiploid" were sterile; very few seeds were harvested from each plant. Furthermore, these seeds have a very low percentage of germination, consequently, the population in each line is very small. Had the population of each line been reasonably large, more definite conclusion can be drawn from these studies. Nevertheless, it can be seen from Table 1 that those plants in the G_7 generation derived from the G_6 generation having somatic chromosomes less than 54, have less chromosomes; but occasionally plants with a higher chromosome number were obtained. The case is typified by lines such as 68, 91, and 92. For example the 5 plants in the line 91, derived from a plant with 52 somatic chromosomes in the previous generation, have 51, 54, 54, 52 and 54 chromosomes respectively. This anomalous segregation certainly deserves some careful analysis. A few lines of plants, derived from plants in the previous generation with a somatic number of chromosomes higher than 54, have more than 54 chromosomes. This is, however, not wholly reliable for there are only several plants involved in a line. From the results obtained so far, the highest chromosome number is 62 and the lowest is 49. It is hoped that selection of this kind be carried on continuously, so that plants with chromosomes either more or less than those have been obtained can be produced. Consequently, in the selection for a lower number of chromosomes, individuals with 18 bivalents will be the ultimate goal.

This is to say that plants resembling *S. faberii* will be the final result. In fact, plants with 51 and 49 somatic chromosomes tend to have more resemblence to *S. faberii* so far as vegetative growth, plant color and type of ear-head are concerned. On the other hand, in the selection for plants with a higher chromosomal number, the limit will be finally reached when plants with 62 and more chromosomes are produced. The nucleo-cytoplasmic ratio of these theoretical individuals will be so upset that they may not be viable. Plants with 62 somatic chromosomes so far obtained are characterized by dark green foliage and short stature. This appears to be some way off from the theoretical limit.

From the aceto-carmine smear preparations, the chromosomal constitution of these 38 plants in G_7 were determined (Table 1). Since the chromosomes of *Setaria* are too small to make detailed study possible, it can be tentatively concluded that most of the chromosomes irrespective of their number, form bivalents. Tetravalents are common in some cells, however trivalents are rarely encountered. In some other cells there are as many as 11 univalents; while there is no univalent at all in many other cells. In plants with more than 54 somatic chromosomes, pentavalents as well as polyvalents are also found. The tetravalents are either in the form of rings or in chains (Fig. 1, 3, 4, 5, 6, 11, and 12); and the trivalents are in the form of chains, rings or triple arcs. Plants such as 118-1, 81-1, 91-2 as shown in Table 1, have 54 somatic chromosomes, but plants such as 105-2, 89-2 etc. behave very much the same way as plants with 54 somatic chromosomes, in spite of their polyvalents and univalents. Accordingly, in the seventh generation after the initiation of this "amphidiploid", plants with a balanced 27 bivalents are yet to be obtained. This is contradictory to the finding of Chen et al. (1). In experimenting with an autotetraploid barley, Chen et al. found some lines with 14 bivalents in one group after 3 or 4 generations since the initiation of the autotetraploid. Let it be a chance variation in the barley autotetraploid, that bivalents are easily formed, but in *Setaria* it is not the case. May be that the nature of the chromosomes of barley favors bivalent formation as in the case of sugarcane (5), Chrysanthemum, *Fragria* and etc. It is hoped, however, that a *Setaria* with just 27 bivalents can be ultimately obtained.

The univalents do not congress at the equatorial plate in MI as the bivalents and polyvalents (Fig. 6 and 11). Instead, they are scattered about in the nucleus. Some remain unsplit and are included in the pole where they are by chance located and many others do join the equatorial plate as laggards after the separation of the bivalents and polyvalents in TI (Fig. 7, 9 and 10). At the equatorial plate the laggards may split and the splitted halves may go to their respective poles. Should the splitted laggards fail to reach the pole, small extra nuclei are ultimately formed. Should they remain unsplit in the first division, they form laggards in AII (Fig. 8) when they begin to divide. Extra nuclei are frequently found in lines 105-2 and 77-1.

Mention must be given to the fact that this "amphidiploid" is a mixture of a tetraploid for genom A and a diploid for genom B, it is better to call them "amphitetra-diploid". Perhaps, the 9 bivalents of genom B have no trouble in pairing unless they fail to compete successfully for the nucleic acid for their reduplication in the process of division with those chromosomes of genom A as postulated by Li, et al.

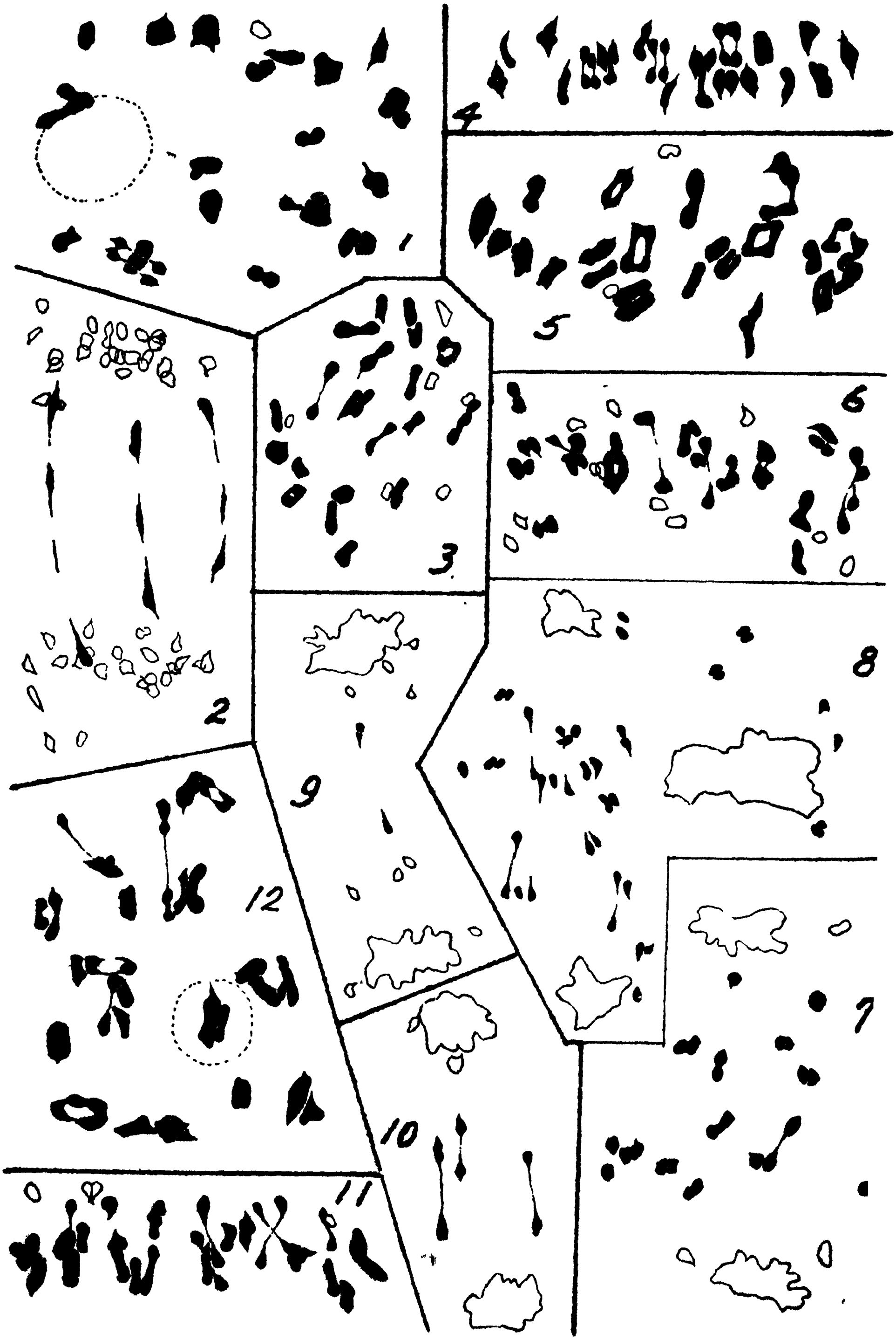

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TABLE I. CHROMOSOMAL CONSTITUTION OF PLANTS IN G_7

G_6 (1947)		G_7 (1948)									
Pedigree	Chromosome number	Pedigree	Stage	Frequency	Chromosomal constitution V	IV	III	II	I	Chromosome number	Remarks
25-1	54	65-1	MI	1				25	3	53	
			AI	1						53	26-27
		65-2	AI	1						51	25-26 with bridges
		65-3	MI	1				26	2	54	
28-1	52	68-1	AI	1						59	31-28
		68-2	MI	1		5		19	1	59	
			Diak.	1	1	2		23		59	
		68-3	MI	1		1	1	19	6	51	
			MI	1		3		17	5	51	
			MI	1				21	9	51	
		68-4	MI	1			1	26	2	57	
30-1	55	73-1	AI	1						60	28-32
		73-2	MI	1		4	1	19		57	
			MI	1				28	1	57	
		73-3	MI	1	2		2	19	2	56	
			MI	1				27	2	56	
30-2	56	74-1	MI	2				31		62	
		74-2	MI	1		4		23		62	
			MI	1		2		27		62	
30-3	54	105-1	AI	1						54	28-26
		105-2	MI	1			2	23	2	54	
			MI	2		3		20	2	54	
			MI	1				24	6	54	
			MI	1		2		20	6	54	
			MI	4		1	1	22	3	54	
			MI	1		1	1	18	11	54	
			MI	1				25	4	54	
			MI	1		4	1	17	1	54	
			MI	1		5		15	4	54	
		105-3	MI	1		3		25		62	
			MI	1		3	1	23	1	62	
			MI	1	1	2		24	1	62	
			MI	1		3		23	4	62	
			MI	1		4	1	21	1	62	
			MI	1		2		24	6	62	
		105-4	MI	1				31		62	
			AI	1						62	30-32
33-2	54	118-1	MI	1				27		54	
33-6	53	77-1	AI	1						58	30-28
			MI	1		2		24	2	58	
			MI	1		2		25		58	
			MI	1		3	1	17	9	58	
			MI	2		2		23	4	58	
			MI	1				27	4	58	
			MI	1				28	2	58	
35-1	57	80-1	MI	1	2		2	20	1	57	

TABLE I. CHROMOSOMAL CONSTITUTION OF PLANTS IN G_7—(*Continued*)

G_6 (1947)		G_7 (1948)									
Pedigree	Chromosome number	Pedigree	Stage	Frequency	Chromosomal constitution V	IV	III	II	I	Chromosome number	Remarks
36-1	54	81-1	AI	1						54	27-27
			MI	1				27		54	
		81-2	MI	1				29	1	59	
37-1	54	82-1	AI	1						57	30-27
41-1	55	86-1	MI	1				27	1	55	
43-7	54	89-1	MI	1		5		18	1	57	
			MI	1		3		22	1	57	
		89-2	MI	1		2		23		54	
			MI	1				25	4	54	
			MI	1		1	2	20	4	54	
		89-3	MI	1		3		19	4	54	
			MI	1				25	4	54	
47-1	56	90-1	MI	1		5		18	1	57	
			Diak	1		3		22	1	57	
49-1	52	91-1	AI	1						51	26-25
			AI	1						51	24-27
		91-2	AI	1						54	27-27
			MI	1				27		54	
			MI	1		2		22	2	54	
		91-3	AI	1						54	28-26
			MI	1			1	24	3	54	
			MI	1		2		23		54	
			MI	1				27		54	
			MI	1		1		24	2	54	
		91-4	MI	1		1		24		52	
			MI	1		2	1	20	1	52	
		91-5	AI	1						54	27-27
			MI	1		2	2	19	2	54	
49-2	51	92-1	MI	1		1		22	1	49	
			Diak.	1		1		21	3	49	
			Diak.	1				23	3	49	
		92-2	AI	2						56	28-28
			MI	1				26	4	56	
		92-3	MI	3		2		22		52	
			MI	1		3		20		52	
			MI	1		1		24		52	
			MI	1		4		18		52	
		92-4	MI	1		1		23	2	52	
49-3	52	93-1	AI	1						51	26-25
			MI	5				25	1	51	
			MI	1		1		23	1	51	
			MI	1				23	5	51	
		93-2	MI	1		1		22	3	51	

(4), for chromosomes of genom B are contributed from the male parent in the original cross. Failure in the competition for nucleic acid would certainly result in non-pairing in the metaphase, as it will be described later that the chromosomes of genom A give rise to some univalents although there is no way of differentiating the chromosomes of each genom. As a result, I am not certain whether or not non-pairing has taken place in the chromosomes of genom B.

Theoretically, chromosomes of genom A ought to form 9 tetravalents. By taking plant 105-2 for instance, 5 tetravalents are encountered. More often, the tetravalents dissociate into two bivalents, or one bivalent and two univalents. In offering to explain an "asynapsis" in the autotetraploid of rye, O'mara (6) gives four possible explanations:

a. Due to spatial relationships within the nucleus of an autotetraploid, the homologous chromosomes have longer and more difficult paths to traverse in order to pair.

b. Due to the location of some chromosomes that the attraction of homology with two other threads are so evenly balanced that the chromosomes may not move so effectively in response to either homologous thread. At least two univalents would thus be resulted.

c. Due to the incomplete and weak associations of homologous chromosomes that univalents split off before the late diakinesis or early metaphase stage are reached.

d. Due to various physiological unbalances of tetraploids, the effect might be generally adverse for normal synapsis. This is a common result of the application of unusual external conditions (heat, cold, and reagents).

It has been mentioned above, that insufficiency of nucleic acid would delay the reduplication; hence there is no crossing over and pairing of the chromosomes in the metaphase. Since the amphidiploid of any plants is obtained with a doubling of its nucleus without the corresponding doubling of its cytoplasm, accordingly, the cytoplasm is probably not enough to supply the increased needs of nucleic acids for the reduplication of the doubled number of chromosomes in division.

O'mara found a significant difference in the percentage of the total number of cells with univalents between the 28- and 29- chromosome groups in the autotetraploid rye. He emphasized that the extra chromosome in the aneuploid introduces an unbalanced condition in the cells which impedes pairing or induces precocious separation of the chromosomes. Furthermore, O'mara's data (6) seem to indicate that the addition of chromosomes to the euploid number has a more serious effect to the progeny than the subtraction of chromosomes, for the magnitude of morphological difference between the 28- and 27- chromosome groups is small. From our data (Table 1), there seems to have no indication of any increase or decrease in the degree of "asynapsis", judging from the number of cells with univalents, either by the addition of one to several or by the subtraction of chromosomes from the euploid of 54 chromosomes. Correctness of this conclusion must depend upon further experimentation.

Chromosomal bridges were found in only one plant 65-2, (Fig. 2). There are as many as three simple bridges were found in one cell. Since no detailed study was made concerning them, we can only say that they are the result of crossing over in heterozygous inversions involving three different chromosomes.

From the random distribution of the univalents, possible non-disjunction of the bivalents, and unequal distribution of the polyvalents, especially the trivalents, I do not expect to have equal anaphase distribution of the chromosomes (Table 1). From this unequal distribution of chromosomes, gametes formed from them will be widely different in their chromosome numbers. Consequently, the zygotes obtained will be in the plus or minus direction from the original number 54. This is exactly the case in the random population of G_6 and the selected segregates of G_7 of *Setaria.*

3. VARIATION IN CHROMOSOMES AND PLANT MORPHOLOGY. A futile attempt was made to associate morphological differences, such as height of plants, length of spikes, and number of tillers (Table 2), with the number of chromosomes. Since this "amphidiploid" was obtained by using some G_2 plants as the female parent, therefore

TABLE 2. MORPHOLOGICAL DIFFERENCES OF THE PLANTS IN G_7

Pedigree	Chromosome number	Leave color	Height (cm.)	Length of spikes (cm.)	Number of tillers	% of aborted pollens (400)	% of aborted seeds (200)
65-1	53	Green	113	10.73	17	13.50	84.00
65-2	51	Light Green	142	14.50	9	14.25	34.00
65-3	54	Light Green	102	11.50	11	16.00	88.55
68-1	59	Green	150	17.38	35	47.00	90.00
68-2	59	Green	182	17.23	119	51.00	98.00
68-3	51	Dark Green	133	15.60	21	31.50	97.50
68-4	57	Dark Green	124	15.35	41	17.00	89.00
73-1	60	Dark Green	125	11.92	97	52.00	86.00
73-2	57	Dark Green	146	16.40	64	14.50	85.50
73-3	56	Dark Green	131	16.33	45	12.00	87.00
74-1	62	Dark Green	115	13.40	80	29.00	81.00
74-2	62	Dark Green	140	16.60	63	22.50	95.00
77-1	58	Dark Green	140	18.40	88	20.50	88.00
80-1	57	Dark Green	147	16.80	26	7.50	82.50
81-1	54	Green	82	11.30	42	36.25	88.50
81-2	59	Light Green	79	13.30	37	16.00	56.00
82-1	57	Light Green	110	13.90	55	8.50	89.50
86-1	55	Dark Green	118	14.93	67	30.00	85.00
89-1	57	Dark Green	139	19.96	61	9.00	91.00
89-2	54	Dark Green	130	15.10	59	14.00	85.00
89-3	54	Dark Green	93	14.20	51	24.25	90.00
91-1	51	Green	140	15.30	111	16.50	86.50
91-2	54	Green	117	18.40	31	19.00	87.00
91-3	54	Dark Green	115	13.40	68	6.00	91.50
91-4	52	Dark Green	102	16.60	51	4.00	97.00
91-5	54	Dark Green	147	17.13	58	17.00	89.50
92-1	49	Green	128	14.80	144	12.00	91.00
92-2	56	Green	108	16.26	48	15.00	54.00
92-3	52	Light Green	98	10.80	20	10.75	53.00
92-4	52	Light Green	107	13.80	18	6.50	68.00
93-1	51	Light Green	88	14.30	55	15.25	51.00
93-2	51	Green	92	10.80	33	18.75	60.50
105-1	54	Dark Green	135	15.60	61	20.75	84.50
105-2	54	Dark Green	169	18.03	76	17.75	87.50
105-3	62	Dark Green	98	13.90	66	25.50	71.00
105-4	62	Dark Green	105	14.80	61	16.50	87.50
118-1	54	Dark Green	126	17.80	27	24.50	92.00

there was a morphological variation in the different lines in the progeny. All plants in certain lines of the G_7 generation seemed to be morphologically uniform in spite of their irregularity in the number of chromosomes, while in some other lines the plants do not show this uniformity. It is interesting to note that plants with a higher number of somatic chromosomes, the foliage is invariably dark green in color. On the other hand, plants with a lower number, the foliage is light green. In general, plants with a lower chromosomal number, that is from 49 to 51, resemble *S. faberii* closely. Some of the ear-heads, randomly chosen from plants with different chromosomal number, are shown in Fig. 14.

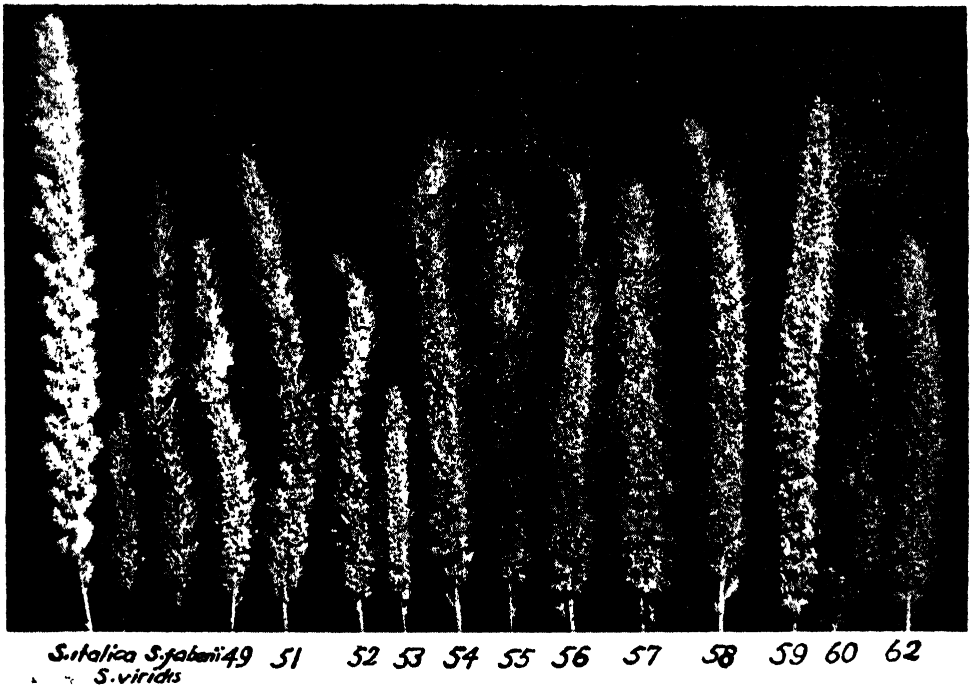

Fig. 14. Earheads of the three species involved in the original cross and random samples of different chromosomal groups of the "amphidiploid". Note that the seeds of the "amphidiploids" are much larger than those of S. italica, the largest of the parental species but most of them are empty.

4. STERILITY. Approximately 400 pollen grains of each plant were examined. The percentage of aborted pollen grains was determined. In the same way, 200 seeds were counted for each plant and the number of aborted seeds was recorded (Table 2 and Fig. 15). There seems to have no association between the percentage of aborted pollen grains and abortive seeds with chromosomal number in different plants; nor is there any association between the aborted pollen grains and abortive seeds. However, there is a tendency that there are increasingly more aborted pollen grains as the number

of chromosomes increases. In general, plants from different lines produce very few good seeds, therefore their high sterility can not be wholly accounted for by the abnormal meiosis as described earlier. There seems to have other physiological disturbance in this "amphidiploid", and the nature of which is still unknown at the present.

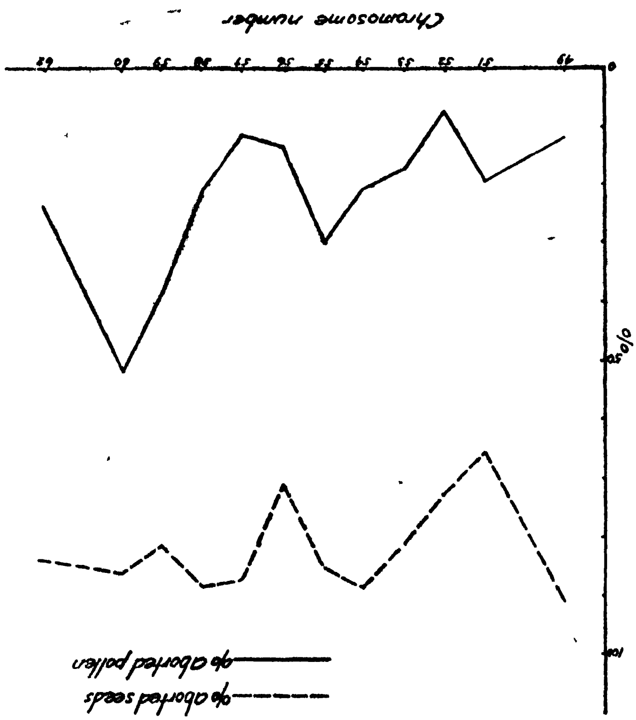

Fig. 15. The relation of % aborted seeds and % aborted pollen grains with the chromosome number in G_7 generation.

SUMMARY

1. G_7 plants of an "amphidiploid" (G_2 of *S. italica* X *S. viridis* and *S. faberii* cultured continuously for 7 generations) were studied. It was found that most of the plants had 54 somatic chromosomes.

2. Meiosis of these plants was studied in detail. "Asynapsis" as evidenced by the existance of univalents was postulated to be the result of insufficiency of nucleic acid.

3. There is no evident association of any morphological difference of the plants with the number of chromosomes.

4. There seems to have a tendency that when the number of chromosomes increases, there are more aborted pollen grains.

5. Very few good seeds were produced by these plants, indicating that there are some physiological disturbance in this "amphidiploid" for sterility other than the disturbance in meiosis.

Acknowledgment: During the course of this investigation, Dr. H. W. Li gave me constant encouragement and help, to whom I am much indebted:

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EXPLANATION OF FIGURES

(All figures are 1250 x)

1. Plant 92-1. Diakinesis showing $1^{IV}22^{II}1^{I}=49$.
2. Plant 65-2. Anaphase with 3 bridges.
3. Plant 68-3. Prometaphase showing $1^{IV}1^{III}19^{II}6^{I}=51$.
4. Plant 92-3. Metaphase with $2^{IV}22^{II}=52$.
5. Plant 105-2. Prometaphase with $3^{IV}20^{II}2^{I}=54$.
6. Plant 105-2. Metaphase with $1^{IV}1^{III}18^{II}11^{I}=54$.
7. Plant 105-2. Telophase I, showing more than ten lagging univalents.
8. Plant 105-2. Telophase II, Telophase in one sister cell showing many lagging univalents. Metaphase in another with univalents scattered around.
9. Plant 89-2. Telophase I, showing one lagging univalent in division.
10. Plant 77-1. Telophase II, showing 3 dividing univalents that lagged behind.
11. Plant 77-1. Metaphase I with $2^{IV}23^{II}4^{I}=58$.
12. Plant 105-2. Diakinesis with $3^{IV}25^{II}=62$.

CULTIVATION OF EXCISED SHOOT TIPS OF ZEA MAYS

TA-CHU LIU

Although works on the cultivation of excised stem tips have been undertaken for several decades, there is less accomplishment when compared with that of excised root tips.

According to Arber (1), the shoots and roots have a fundamental correspondence and the shoots can give rise to roots. But as far as the condition for root formation on excised stem tips is concerned, results are contradictory according to the species used as the test material (2). In the present work, the author, by cultivating young shoot tips of *Zea mays* L. *in vitro,* expects to find out the effect of rooting in artificial environmental conditions, such as light and temperature.

MATERIAL AND METHODS

Selected seeds of *Zea mays,* collected in 1947 in the field of the Institute, were soaked in tap water for 4 hours, then immersed in 0.1% alcoholic sublimate solution for 4-5 minutes. The soaked seeds were washed five times with sterilized distilled water. Each group of 20 seeds was put in a sterilized Petri dish on a sheet of moist filter paper. Finally the dishes were kept in an incubator at 25°C for germination. 3 days after, shoots with coleoptiles about 1-1.5 cm. in length were excised at three different levels: Group (a) at 1/3 the length of the coleoptile from its tip, Group (b) at 2/3 the length of the coleoptile from its tip, and Group (c) just beneath the base of the entire coleoptile. The excised shoot tips were transferred into culture medium for cultivation.

White's solution with 2% sucrose and 500 ppm. yeast extract was used as the culture medium (4). All the procedures were similar to the previous work of the author (2).

For the effect of light, the three excised groups of shoot tips were cultured under light and in darkness. For the effect of temperature, similar groups were cultured at an ordinary and a higher temperature. The experiments were carried out from April to August. 480 cultures were accumulated by the author. The growth features were observed from time to time with special attention to the root production and chlorophyll development on the excised shoots. For histological studies, cross and longitudinal sections were cut from time to time through the junction of root and shoot in order to acertain the orientation of rooting.

RESULTS

1. THE EFFECT OF LIGHT.—The growth phenomena of the excised shoot tips cultured under diffused light, at 23-26°C, were as follows: Group (a)—On the 3rd day of the experiment, the inner leaves of the excised coleoptile tip began to extend lengthwise in the coleoptile with their cut edges curved outward. The tissue became green at the same time. On the 17th day, the two pieces of expanded leaf apexes slipped out from the horn shaped coleoptile and scattered freely in the culture solution. The cut edges of these leaf fragments had some crevices along the veins. On the 30th day, the color

of the fragments began to fade. The fragments ceased to grow on the 38th day, their color became brown and were apparently in the process of decaying. Group (b)—There were same leaf fragments exhibiting similar growth features as those in Group (a). Group (c)—Elongation of the shoot and chlorophyll development were evident on the 3rd day. On the 7th day, the 1st leaf set forth through the tip of the coleoptile and roots about 0.2 cm. in length developed at the base where the 1st node of the stem is located. On the 18th day, the longest root reached 7.5 cm. long, while the coleoptile became brown indicating decomposition. On the 30th day, roots produced from the newly developed nodes in each culture grew vigorously; meanwhile, the leaves at the basal nodes began to fade and decompose. Fig. 1 shows the different stages of development of shoot tips in Group (c).

In general, the growth phenomena of Groups (a), (b) and (c) in darkness, at 22-24 °C, were similar to those under light, but the tissues grown in darkness showed less growth than those under light: On the 26th day, the leaf fragments of Groups (a) and (b) became brown in color. On the 45th day, their growth were apparently at a standstill. On the 8th day, root developed on the excised shoots of Group (c); and it reached 1.5 cm. in length on the 18th day. On the 45th day, the growth of the shoots and roots kept on normally. They were in the process of decaying from the 58th day on. Fig. 2 shows the growth features of Group (c) on the 30th day.

Fig. 1. i, ii, iii showing the excised shoot tips grown under diffused light, at 23-26°C, for 29, 49 and 69 days, respectively.

Fig. 2. Showing the excised shoot tips grown in darkness, at 22-24°C, for 29 days.

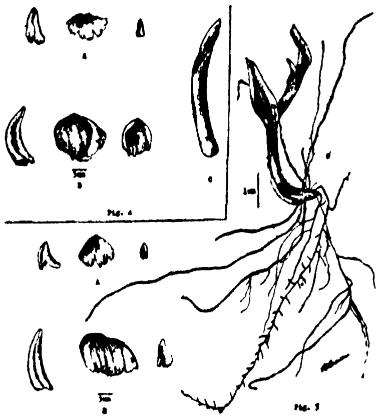

Fig. 3. A, B, C showing the excised shoot tips grown at an ordinary temperature (20-24°C) in a dark room, for 39 days.

Fig. 4. A, B, C showing the excised shoot tips grown at a higher temperature (34-35°C), in an incubator, for 39 days.

II. THE EFFECT OF TEMPERATURE.—The growth phenomena of Groups (a), (b) and (c) at 20-24°C in a dark room were similar to those mentioned above: The tissues of Groups (a) and (b) ceased to grow on the 45th day. In Group (c), the root began to develop on the 8th day and grew very well till the 58th day, when all the shoots were completely decomposed. Fig. 3 shows the growth features of these three Groups on the 40th day.

The growth phenomena of excised shoots at 34-35°C in an incubator were similar to those at 20-24°C, except that there was no root formation even in Group (c): The leaf fragments of Groups (a) and (b) expanded and scattered in the medium on the 20th day, and growth ceased on the 45th day. As to the shoots in Group (c), their tips became light yellow in color with a little elongation on the 8th day. On the 12nd day, their growth rate was slowed down and the rate was reduced to complete ceasation on the 35th day. No trace of root was observed. On the 45th day, they were completely decomposed. Fig. 4 represents the growth features of the shoots of these three Groups on the 40th day.

From histological studies, it was found that the root is endogenously derived from the meristematic ring tissue on the node of the stem.

The results of the foregoing experiments showed definitely that: 1. in the culture of excised shoot tips, root formation occurs both under light and in darkness, but not at high temperature, and 2. under the present experimental conditions, a portion of the coleoptile without node can not develop into a complete plant.

DISCUSSION

It is evident that the initial excised tissue which is of a length 1/3 or 2/3 of the original coleoptile without any nodal tissue can not grow and produce roots *in vitro*. It expands to some extent, but owing to the deficiency of meristematic tissue, soon it ceases to grow. It is a well known fact that the growing point of a foliage bud is located at the base of a young leaf, and the root initiates in intimate contact with the ring of meristematic tissue on node (3). This is the reason why only the tissue which contains the node grows and produces roots in an artificial medium. Thus the presence of meristematic tissue is an internal factor governing the growth and development of an excised shoot.

Light has been usually regarded as an important external factor in the growth and root formation of the excised shoot. Although it is true that the excised shoot grows better in the presence of light than in darkness, yet the effect of light on the root formation is doubtful. According to previous investigation on the excised plumules of *Nelumbo speciosum* by the author (2), light is not a limiting factor for root formation of excised shoot tip *in vitro*. The results of the present work with the excised shoot of *Zea mays* confirm those of the previous one. On the other hand, temperature seems to be a very important factor in root formation. Higher temperature inhibits the root formation of excised shoot tips of *Zea mays in vitro.*

SUMMARY

Excised shoot tips of *Zea mays* were cultured in White's solution under aseptic conditions. The roots were produced on the node either under light or in darkness.

Excised shoot tips of *Zea mays* produce roots on the nodes at 20-24°C; but no trace of root at 34-35°C. The higher temperature tends to inhibit the root formation.

The author is deeply grateful to Dr. T. L. Loo, the Director of the Institute, for his direction and criticisms. He also wishes to express his thanks to Dr. F. H. Wang, for his kind help on the histological studies.

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STUDIES ON THE CRUCIFERAE OF CHINA, I.

TAI-YIEN CHEO

Cruciferae(1) is a large group of plants. In China there are about fifty genera and three hundreds species. The writer attempts to have a general survey of this family, and plans to report successively. The present paper is a preliminary report on the genera *Arabis* and *Draba*, including 17 species, 6 varieties, 1 form and 1 prole. The study was made with materials preserved both in the herbarium of the Institute and in the herbarium of the University of Nanking. In the citation of the specimens, those from the latter are indicated by (HUN).

The work is carried on under the direction of Dr. C. P'ei to whom the writer wishes to offer his gratitudes for the valuable instructions and help in preparing the manuscript. To Dr. A. N. Steward, curator of the Herbarium of the University of Nanking, he also wishes to express his sincere thanks for the permission to make use of the University specimens during the progress of the study.

1. Fruit a silique, long, linear; seeds 1- or 2-seriate, many, more or less winged; flowers often white, rarely purple .... *Arabis*.
1. Fruit a silicle, very short (longer than broad); seeds 2-seriate, several or many, not winged; flowers yellow or white, rarely purple .... *Draba*.

ARABIS Linnaeus

Erect or spreading annual, biennial, or perennial herbs, rarely subshrubby, covered with simple, forked or branched, sometimes stellate hairs; leaves entire, lobed or pinnatifid, radical ones rosulate, spatulate, petiolate; cauline leaves sessile, often auricled or dilated amplexicaul at the base, rarely petiolate; flowers in terminal racemes or spikes, usually small; sepals erect-spreading, ovate to elliptic-linear, lateral ones subsaccate, all apices obtuse, slightly hairy on the dorsal side; petals white, rarely purple or rose-colored; lamina obovate to oblong-cuneate, apex entire or sometimes slightly emarginate, base distinctly clawed; stamens 6, tetradynamous, anthers oblong or subelliptic, rarely suborbicular, apex often recurved, rarely erect; filaments slender, often dilated toward the base; pistil linear, style filiform, very short, sometimes nearly none, rarely elongate; stigma often truncate, rarely capitate or shortly bilobed; silique linear, long, compressed, erect, spreading or pendulous, biloculed, many-seeded, dehiscent; septum narrow and membranaceous; valves flat, 1-nerved or nerveless, with a short persistent style; seeds numerous, 1 or 2 seriate in each cell, pendulous, ovoid or orbicular, compressed, marginate or rarely all immarginate, reddish brown or dusky in color; cotyledons accumbent.

There are about 200 species of world distribution, abundant in N. Asia, Europe, and N. America, rare in the S. hemisphere. 25 species are recorded in China, most of them are distributed in the N. and S. Western provinces.

(1) The family description is given in *"The Cruciferae of Eastern China"*, Bot. Bull. Acad. Sinica 2(3):178. 1948.

1. Plant with stolen or runner 2
1. Plant without stolen or runner 3
2. Herb with stolon; flowering stem about 5 cm. high; cauline leaves oblong, with serrate margin .... *A. serrata.*
2. Herb with runner; flowering stem 10-15 cm. high; cauline leaves obovate, with denticulate margin .... *A. aff. flagellosa.*
3. Stem sulcate 4
3. Stem not sulcate 6
4. Fruiting pedical filiform, stout, purplish, glabrescent, 10-5 mm. long; stem often paniculate branching from the middle .... *A. paniculata.*
4. Fruiting pedicel filiform, slender, hairy or glabrous, about 2 mm. long 5
5. Leaves with stellate hairs on both sides; silique often pendulous; pedicel with stellate hairs. *A. pendula.*
5. Leaves subglabrous above, with stellate hairs beneath; silique spreading; fruiting pedical glabrous .... *A. ambigua.*
6. Low herb, not over 15 cm. high 7
6. Erect herb, 30-50 cm. high 8
7. Plant densely covered with biforked or cross like hairs; stem 1-few, radiating from base; flowers in corymbose-raceme; cauline leaves ovate-lanceolate, subentire, clasping at the base ..... *A. Stelleri.*
7. Plant glabrous; stem branching near the base; flowers in elongated racemes; cauline leaves oblong to ovate-oblong, entire, auriculate at the base .... *A. oxyota* var. *glabra.*
8. Stem often simple, glabrous above; cauline leaves with sagittate-clasping base and entire margin; silique strictly erect and appressed .... *A. glabra.*
8. Stem simple or branched, hirsute; cauline leaves with auricled-clasping base and dentate margin; silique erect to spreading .... *A. hirsuta.*

Arabis serrata Franch. et Sav., Enum. Pl. Jap. 1:33, 1875; l. c. 2:278, 1879.

Small herb, with perennial root and stolon; flowering stem about 5 cm. high, covered with appressed simple and forked hairs; radical leaves 2.5-3 cm. long, 0.7-1 cm. broad, spatulate, dentate, base tapering, with substellate hairs on both sides; cauline leaves few, small, oblong, acute, serrate, base amplexicaul; flowers in short corymbose raceme, sepals 3.5-4 mm. long, 1.5-2 mm. broad, ovate, obtuse, lateral ones subsaccate, all slightly hairy on dorsal side; petals 6-7 mm. long, 2.5-3 mm. broad, obovate, subtruncate or slightly emarginate at apex, base cuneate and shortly clawed; stamens 6, 5:6 mm. long, anthers oblong, filaments dilated toward the base; pistil about 5 mm. long, linear, slender, style very short, stigma truncate; pedicels 6-2 mm. long, slender, nearly filiform, densely covered with simple and forked hairs.

Hunan: Tao-ling, *Prof. Tsoong,* Mar. 3, 1910. (HUN)

Distrib.: Type locality in Japan.

This is a small herb with stolon and short flowering stem bearing few small leaves with serrate margin, while the spatulate leaves are in rosettes at the base.

Arabis aff. flagellosa Miq., Ann. Mus. Bot. Lugd.-Bat. 2:72. 1865-66.

Herb, with many stems and runners from the root, vegetative runners often decumbent, 20-35 cm. long, flowering stem erect but short, only 10-15 cm. high, covered with biforked hairs; radical leaves spatulate-oblong, narrowly petioled, obtuse, unequally dentate to serrate, about 7 cm. long and 1.5 cm. wide; runner leaves loosely arranged, 3-5 crowded at the tip, obovate, obtuse, narrow at the base, sessile, somewhat clasping, slightly serrate or denticulate, 2-3 cm. long and 0.8-1.3 cm. wide; leaves several on the flowering stem, smaller; all leaves covered with cross-like forked hairs

on both sides when young, less or glabrescent above with the age; immature silique-racemes terminal, narrow-linear, compressed, about 40 mm. long and 1 mm. wide, tipped with a 1 mm. long style and stigmatic end; valves smooth, nerveless; immature seeds 1-seriate; fruiting pedicel filiform, erect-spreading, 14-5 mm. long, with branched hairs.

Kiangsu: Chong-wu-kia, Hufu, I-hing, *C. Y. Luh 450,* Apr. 18, 1933. "Herb, under shade".

Chekiang: Hsi-tienmu-shan, *H. Migo,* Apr. 23, 1936.

Distrib.: This species was originally found in Japan, and it is now recorded in the eastern provinces of China.

The specimens cited above match well with the general habit of the Japanese species *A. flagellosa* Miq., from which it differs in long silique and short persistent style, and slightly dentate leaf-margin. This is probably why that H. Migo named this plant collected from Chekiang kept in our herbarium as *"A. chekiangensis"*, but no original description of H. Migo can be found. It is quite possible that H. Migo has not yet published the description of this plant, although he might consider it as a new species. The writter has only fruiting specimen at hand, therefore it is better to make the final determination later when flowering specimens are collected.

ARABIS PANICULATA Franch., Pl. Delav., 57, 1889.

A. alpina var. *rigida* Franch., Bull. Soc. Bot. Fr., 33:401, 1886.

Annual herb, 1/3-1 m. high, covered with simple or branched hairs, some stellate; stem erect, often paniculately branched from the middle, usually leafy at the apex; radical leaves rosulate, oblong, obtuse to subacute, entire to obscurely denticulate; cauline ones very small, oblong, remotely denticulate, erect, sessile to obscurely amplexicaul; flowers in racemes, sepals erect, white margined, obtuse; petals erect, 2 or nearly 3 times as long as the calyx, white, limb ovate-oblong; silique 4-6 cm. long and 1/10 cm. broad, slightly curved upwards, narrowly linear, 1-nerved, tapered by a very short persistent style, stigma capitate; pedicel filiform, stout, 10-5 mm. long; seeds small, ovoid-oblong, brown, narrowly winged.

Kweichow: Weining, Y. *Tsiang 9098,* Oct. 5, 1930, "along roadside".

Distrib.: Also in Yunnan.

This species is distinguishable from the others by its paniculate branches from the middle of the stem.

ARABIS PENDULA L., Sp. Pl. 665. 1753.

Herb, 1/3-2/3 m. high, more or less woody at the base; stem simple or branched, sulcate, hispid, mingled with stellate hairs; leaves 5-10 cm. long and 2-3 cm. wide, amplexicaul, oblong, dentate, sometimes unevenly or undulately dentate, acuminate at the apex, dilated or somewhat cordate at the base, with stellate hairs on both sides, and scattered with sub-appressed simple hairs pointing obliquely forward in the forepart of the upper surface; upper leaves narrowly elliptic to lanceolate, nearly entire or slightly serrate; flowers in long and loose racemes, sepals ellipticly linear, 3 mm. long and 1 mm. wide, with a few stellate hairs on the dorsal side; petals white, oblong, clawed, 4-5 mm. long and 1.5 mm. wide; stamens 6, filaments dilated toward the base,

2-3 mm. long; pistil linear, with stigmatic point at the tip, pedicel about 3 times as long as the calyx; silique linear, compressed, spreading and pendulous, 1-nerved, 6-9 cm. long and 1/10 cm. wide; fruiting pedicel filiform, slender, about 2 cm. long, scattered with stellate hairs.

Shantung: Tai-shan, Y. *Yabe,* Aug. 30, 1925.

Shansi: Wu-tai-shan, Y. *Yabe,* July 16 et 18, 1907.

Hopei: Miao-fung-shan, Y. *Yabe,* without date; Pai-hwa-shan, Y. *Yabe,* July 28, 1905; Tieh-lin-sze, Hsiao-wu-tai-shan, Y. *Yabe,* July 29 et Aug. 1, 1906. Fu-ling-hsien, *T. F. Li 54,* Oct. 5, 1925, "North valley, under grasses; vernacular name: Wai-pe-tsai" (HUN); Y-hsien, *K. M. Liou 2567,* June 24, 1934 (HUN); Lai-yuan-hsien, *K. M. Liou 2961,* July 22, 1934. (HUN)

Szechuan: Without precise locality, *T. Tang 23440,* 1930.

Liaoning: Kung-chu-ling, Y. *Yabe,* Aug. 1, 1910; Ho-shang-shan, Chingchow, Y. *Yabe,* Aug. 28, 1910.

Distrib.: Also reported from Yunnan, Mongolia, Kirin and Siberia.

This species is easily recognized by its long, linear, pendulous siliques in elongated and loosely terminal racemes.

ARABIS AMBIGUA DC., Syst. 2:231. 1821.

Perennial herb, about 1/3 m. high; stem sulcate, much branched, scattered with few stellate hairs; leaves amplexicaul, subglabrous above, with stellate pubescence beneath, basal ones oblong, entire or somewhat dentate, upper ones oval-lanceolate, entire or denticulate; flowers in terminal racemes, sepals erect, greenish, ovate-linear, obtuse at apex, truncate at base, about 2.5 mm. long and less than 1 mm. broad, stellate hairs present when young; petals white, membranaceous, oblong, narrow toward the base, 3 mm. long and 1 mm. broad; stamens 6, tetradynamous, anthers basifixed, inner filaments about 2.5 mm. long, outer ones 2 mm. long; pistil linear, stigma capitate, sessile, pedicel filiform, more than twice as long as the calyx; immature siliques spreading, linear, compressed, 1-nerved, about 4.6 cm. long and 1/10 cm. cm. broad; fruiting pedicel glabrous, 1.5-1.75 cm. long.

Shansi: Without precise locality, alt. 6000-7000 ft., *T. Tang 1154,* July 19, 1929, "on roadside".

Distrib.: Only recorded in Shansi.

This plant was identified as *A. alphina* L. by E. D. Merril, but it is quite different from the original description of this species. Although there is no type specimen available to compare with, yet this plant matches well with the Kew specimen of *A. ambigua* DC. *1355* (R. C. Ching's Photo *01021,* kept in the Herb. of the Inst.). It differs from *A. pendula* L. by its subglabrous, much branched stems; less pubescent leaves with stellate hairs beneath, not hispid above; and glabrous fruiting pedicels.

ARABIS STELLERI DC., Syst. 2:242. 1821.

A. pendula Steller, DC. l. c.

A. camtschatica Willd., DC. l c.

Low herb, rough and densely hairy, the hairs often biforked and cross-like; stem only a few inches high, 1-several growing up from the root; radical leaves 3-5 cm.

long and 1-1.5 cm. broad, rosulate, oblong-spatulate, obtuse, dentate, narrowly petioled; cauline leaves smaller, ovate-lanceolate, subentire, clasping at base; flowers crowded, in terminal corymbose-racemes; sepals obovate, narrow and truncate at the base, about 5 mm. long and 1.5 mm. broad, lateral ones somewhat saccate at the base; petals white, cuneate-oblong, slightly clawed, twice as long as the calyx; stamens 6, inner filaments 6 mm. and outer ones 5 mm. long; pistil linear, with short style and capitate stigma, pedicel densely hairy; silique examined immature.

Chekiang: Hangchow, *The Heude Museum,* Shanghai.

Distrib.: Only recorded in Chekiang.

This is a low herb with corymbose-raceme. It is often densely covered by biforked or branched cross-like hairs.

ARABIS OXYOTA DC. var. GLABRA, var. nov.

Herba humilora, glabra. Foliis caulinis oblongo-ovatis, amplexicaulis, basi auriculis inaequilateralis, integerrimis, paulo-incrassatis.

Herb, about 15 cm. high, glabrous; stem short, somewhat flexuose, branched; leaves more or less fleshy, amplexicaul, oblong to ovate-oblong, entire or slightly undulate, obtuse, inaequilateral auriculate at the base, about 1 cm. long and half as wide; flowers small, in terminal racemes, elongated; sepals greenish, ovate, 1-1.5 mm. long and ½ mm. broad; petals pinkish white, obovate, shortly clawed, about ¾ times as long as the calyx; stamens 6, 1-1.25:1.5-2 mm. long, anthers dorsifixed, filament slender, slightly broader near the base; pistil linear, stigma sessile, depressedly capitate; silique linear, slightly curved upward, about 15 mm. long and 1 mm. broad; valves slightly convex, 1-nerved, with stigmatic point at the apex, fruiting pedicel filiform, nearly horizontal, 6-3 mm. long; seeds 2-seriate, very small, oblong.

Kiangsu: Haichow, *The Heude Museum 38560,* Shanghai, Apr. 20, 1926. Varietal type.

This plant was primarily labeled as *A. auriculata* Lam. in the Heude Museum at Shanghai, it is obviously different from the original description by Lamarck given in Encycl. 1:219, 1783, but it agrees with the Kew specimen of *A. oxyota* DC. *980* (R. C. Ching's Photo *01022,* kept in the Herb. of Inst.), and the description of DeCandole given in Syst. 2:236, 1821. Although the writer has not seen the DeCandole's specimen, yet he thinks that this plant might be identical with *A. oxyota* DC, from which it differs only in having inaequilateral auriculate base, entire leaf margin, and whole plant glabrous. Therefore a new variety is proposed by the writer.

ARABIS GLABRA (L.) Bernh., Britt. et Brown., Ill. Fl. 2:181. 1913.

Turritis glabra L., Sp. Pl. 666. 1753.

Arabis perfoliata Lam., Encycl. 1:219. 1783.

Arabis glabra Bernh., Verz. Syst. Erf. 195. 1800.

Biennial herb, about ½ m. high, glabrous above, hairy at the base; stem erect, nearly simple; radical leaves petioled, oblanceolate or oblong, dentate or sometimes lyrate, with simple and branched hairs; cauline leaves sessile, with a sagittate base, amplexicaul, glabrous, entire, lanceolate to ovate-oblong, acutish or acuminate, 2.5-3 cm. long and less than 1 cm. wide; flowers in terminal racemes, sepals erect, lanceolate,

truncate at the base, about 4 mm. long, lateral ones saccate; petals yellowish white, oblong, long clawed, one and half longer than the calyx; stamens 6, anthers basifixed, filaments dilated toward the base, nearly 4 mm. long; pistil linear, stigma subsessile, entire; silique narrowly linear, about 5 cm. long and less than 1/10 cm. wide, nerveless, with very short style and depressed stigma at the apex, strictly erect and appressed; fruiting pedicels 10-6 mm. long; seeds very small, marginless.

Sinkiang: Cheng-hua, alt. 1800 m., *C. Lin 245,* "on grass land."

Distrib.: New record from Sinkiang.

This species is easily recognized by its strictly erect and appressed siliques and pedicels. The whole plant is glabrous above and hairy at the base.

ARABIS HIRSUTA (L.) Scop., Fl. Carniol. ed. 2, 2:30. 1772.

Turritis hirsuta L., Sp. Pl. 666. 1753.

Arabis ovata Poir., Lam. Encycl. Suppl. 5:557. 1817.

Annual herb, 30-40 cm. high, with long, simple and branched hairs, mostly forked; stem erect, simple or branched; radical leaves oblong or spatulate, obtuse, dentate, narrow toward the base; cauline ones ovate or oblong-lanceolate, dentate to denticulate, amplexicaul by an auricled base, 2-5 cm. long and 0.7-2 broad; flowers in terminal racemes, sepals erect, elliptic, 2 mm. long and 1 mm. wide, lateral ones little broader and more or less saccate at the base; petals white, membranaceous, oblong, clawed, 5 mm. long and 2 mm. broad; stamens 6, tetradynamous, filaments dilated toward the base, inner ones 3 mm. long and outer ones 2.5 mm. long; pistil linear, stigma capitate, with nectary glands at the base; pedicel about one and half as long as the calyx; siliques erect to spreading, linear, compressed, tapered by the very short style and depressed stigma, 3-4 cm. long and 1/10 cm. wide; valves nerveless; fruiting pedicel filiform, glabrous, 10-5 mm. long; seeds oblong or nearly orbicular, narrowly winged.

Szechuan: Kingfushan, Nanchuan, *Y. Y. Ho 4617* et *4762,* June 11 et 17, 1935, "on grassy slope".

Sikang: Without precise locality, *K. L. Chu 7020,* 1940.

Distrib.: Also in Korea and Manchuria.

This species is characterized by its spatulate radical- and oblong to ovate cauline-leaves with dentate margin and the whole plant is densely covered with simple and branched hairs.

DRABA Linnaeus

Winter-annual, biennial, or perennial herbs, suffruticose, often low, caespitose, covered with various kinds of hairs, though often forked or stellate; stems leafy or scapose; leaves simple, entire, dentate, or denticulate, basal ones rosulate, petiolate, cauline ones sessile, more or less amplexicaul; racemes bare or bracteate, flowers small or medium in size; sepals erect-spreading, outer ones oblong or elliptic, inner ones broad, often ovate, base not or little saccate, all apices rounded or somewhat obtuse, hyaline marginate, often hairy on dorsal side; petals yellow or white, rarely orange-yellow, lilac, violet- or rust-coloured; lamina obovate-cuneate, the apex often slightly emarginate, the base gradually shortens and narrows into a claw; stamens 6 (sometimes the shorter pair abortive), erect or ascendent; filaments thin or gradually dilated toward

the base, rarely greatly dilated; anthers ovoid, or oblong, apex obtuse; pistil in broad or narrow flask-shape, rarely cylindric; ovary with 4-80 ovules; style conical or filiform, sometimes nearly none or elongate; stigma depressedly capitate, sometimes broad, rarely manifestly bilobed; silicle not more than 3 times as long as broad, ovoid or lanceolate, sometimes oblong or linear, erect or curved, not rarely contorted, biloculed, dehiscent; septum broad and membranaceous; valves flat, rarely convex, glabrous or pubescent, nerveless, or with a mid-nerve manifestly downward, evanescently upward, style persistent; seeds several or numerous, 2-seriate in each cell, ovoid, or ellipsoid, compressed, 0.5-1.5 mm. long, dilute brown, wingless or rarely winged; cotyledons accumbent, rarely incumbent.

There are about 250 species of world distribution. They are mostly distributed in the high mountainous Europe, Asia, and America, or confined to the high northern and southern polar regions. Few are found in the temperate habitat. There are about 30 species recorded in China, most of them in the N. and S. Western China.

1. Plant simple or branched, scapeless 2
1. Plant tufted, presence of scape 7
2. Annual herb; racemes long, with nearly horizontal-spreading pedicels; silicle elliptic-oblong, 5-8 mm. long, 2-3 mm. broad; valves pubescent, without midrib and style .... *D. nemorosa.*
2. Perennial herbs 3
3. Plant simple; racemes long, lower flowers not bracteate; silicle ovate, often contorted; cauline leaves ovate-lanceolate, amplexicaul .... *D. amplexicaulis.*
3. Plant tufted; racemes short, lower flowers bracteate 4
4. Stems erect. 5
4. Stems ascendent, sucker elongate and often rooting .... *D. surculosa.*
5. Racemes terminal, dense, then elongate 6
5. Racemes terminal, sometimes also axillary; cauline leaves ovate-oblong, acuminate, subamplexicaul, 1-3-denticulate on each side of the margin; silicle glabrous, elliptic, both ends acute . *D. mongolica.*
6. Cauline leaves 3-5, obovate-spatulate, rounded at the apex, while the base tapers into an indistinct petiole, margin entire .... *D. oreodoxa.*
6. Cauline leaves 3-9, oblong-lanceolate, acutish at the apex, slightly amplexicaul at the base, margin entire or slightly denticulate .... *D. yunnanensis.*
7. Scape leafless 8
7. Scape leafy or leafless 9
8. 3-5 flowers in umbel-like raceme, pedicels about 1.5 mm. long; rosette leaves narrowly obovate, obtusish, entire, densely covered with greyish-white simple, forked and stellate hairs.... *D. senilis.*
8. 3-8 flowers in corymbose-racemes, pedicels 6-3 mm. long; rosette leaves obovate, rounded, entire, covered with minutely substellate hairs or glabrescent .... *D. involucrata.*
9. Flowers in short corymbose raceme with few lower flowers bracteate, somewhat involucrate...... .... *D. lichiangensis.*
9. Flowers in umbel-like raceme with lower flowers ebracteate........ 10
10. Scape sometimes 1-leaved, 5-7 cm. high; pedicels 9-5 mm. long; leaves densely covered with simple and forked hairs on both sides .... *D. oreades* prol. *chinensis.*
10. Scape leafless, within 5 cm. high; pedicels not more than 6 mm. long; leaves hairy or glabrous.. 11
11. Scape and pedicel within 3 mm. in length; leaves glabrous or with simple and forked hairs on both sides .... *D. oreades* var. *commutata.*
11. Scape 1-5 cm. long, with smaller flowers; pedicels 6-2 mm. long; leaves often glabrous........ .... *D. oreades* var. *Tafelii.*

DRABA NEMOROSA(2) Linn., Sp. Pl. 643. 1753.

D. nemorosa L. β *hebecarpa* Lindbl., Linnaea 13:333, 1839; Ledeb., Fl. Ross. 1:154. 1842.

Hopei: Hsiao-wu-tai-shan, *Y. Yabe,* July 30, 1906.

Kiangsu: Nanking, *L. F. Tsu 333,* Apr. 17, 1920 (HUN); same locality, *A. N. Steward 38,* Mar. 17, 1922. "Roadside, flowers yellow". (HUN)

Shantung: Nan-tien-men, Tai-shan, alt. 3000 ft., *C. Y. Chiao 2160* et *2184,* May 1, 1929. (HUN)

Distrib.: Also recorded in Shensi, Mongolia and Jehol.

DRABA AMPLEXICAULIS Franch., Bull. Soc. Bot. de Fr. 33:403. 1886.

Perennial herb, 30-60 cm. high, with simple, forked and stellate hairs, stem erect, simple or branching above; basal leaves broadly lanceolate, acute, entire or remotely denticulate; cauline leaves ovate-lanceolate, acute, base semiamplexicaul, margin subentire or distantly denticulate, 2-3.5 cm. long, 0.4-1.5 cm. broad, all with simple and forked hairs above and stellate below; racemes corymbose and crowded, very elongated after flowering, flowers rather large, naked or lower ones 1-2 bracteate; sepals 3-3.5 mm. long, outer ones oblong, obtuse, inner ones ovate, obtusish, saccate at base, all pilose on dorsal sides; petals yellow, 6-8 mm. long, lamina obovate, apex emarginate, base cuneate into a short claw; stamens 6, about 4 mm. long, filaments broadly dilated toward base; ovary oblong-ellipsoid, glabrous, stigma depressed; silicle elliptic-ovoid, often contorted and apex incurved, glabrous, 5-8 mm. long and 3 mm. broad, terminated with a short style; fruiting pedicel 2.5-1 cm. long, subrectangular, erect-spreading to nearly horizontal.

Yunnan: Yangtze watershed, Prefectural District of Likiang, eastern slopes of Likiang Snow Range, alt. 12-14000 ft., *J. F. Rock 4462,* May-Oct. 1922. (HUN)

Szechuan: Without precise locality, *T. Tang 23462,* 1930; Ching-ting, Mt. Omei, *Y. Y. Ho 6206,* Aug. 20, 1935. "On grass land."

Sikang: Mountains of Kulu, east of Muli Gomba, alt. 3650-4425 m., *J. F. Rock 16468,* June 1922, "flowers yellow". (HUN) Jedo Pass, 40 li northwest of Tachienlu, alt. 1500 ft., *A. Chen Young 194,* July 16, 1934. "Mountain side; flowers bright yellow".

Distrib.: Also recorded in Kiangsi.

This species is easily recognized by its elongate raceme with sub-horizontal-spreading pedicels and ovate-elliptic, often contorted silicle. It is closely related to *D. surculosa* Fr. from which it differs by the characteristics mentioned above.

var. BRACTEATA O. E. Schulz, Das Pflanzenr. 4(105):180. 1927.

Plant with above 24 flowers on the lower part of the elongated raceme. Each flower is provided with a leafy bract.

Yunnan: Without precise locality, *G. Forrest 11974* (Co-type), 1913. (HUN)

var. DASYCARPA O. E. Schulz, l. c. 181.

Silicles densely covered with stellate hairs.

Yunnan: Region of Tungshan, Yangtze drainage basin, east of Likiang, *J. F. Rock 10533* (Co-type), Aug. 1923. "Rocky slope." (HUN)

var. DOLICHOCARPA O. E. Schulz, l. c.

(2) Species description is given in the Bot. Bull. Acad. Sinica, 2(3):186. 1948.

Immature silicle elongate, narrowly lanceolate, 10-11 mm. long, base 2.5 mm. broad, sometimes subcontorted.

Yunnan: Yangtze watershed, Prefectural District of Likiang, eastern slopes of Likiang Snow Range, *J. F. Rock 6066* (Co-type), 1922. (HUN)

DRABA SURCULOSA Franch., Bull. Soc. Bot. de Fr., 33:401. 1886.

D. surculosa Fr. f. *elatior* Schulz, Das Pflanzenr. 4 (105): 181: 1927.

Perennial herb with slender rhizome, sucker elongate and often rooting; stem erect, very simple, bearing 8-15 leaves, shortly pilose; basal leaves obovate-cuneate, obtuse; cauline leaves oblong or ovate-oblong, obtusish, remotely denticulate to entire, base semiamplexicaul, covered with simple and forked hairs on both surfaces; flowers in short terminal racemes, few lower flowers with leafy bracts; sepals obovate, 2.5 mm. long, 1.25 mm. broad, obtuse, lateral ones saccate at the base, sparsely pilose on dorsal side; petals yellow, broadly obovate-cuneate, slightly emarginate at the apex, shortly clawed at the base, 6-7 mm. long, 2.5-3 mm. broad; stamens 6, filaments dilated near base; pistil elliptic; immature silicle elliptic, flattened, glabrous, about 6 mm. long and 2.5 mm. broad, valves nerveless, style 0.75-1 mm. long, coronate; fruiting pedicel curved-spreading, pilose, more than twice as long as the silicle.

Yunnan: Between Likiang, Tungshan, Tuinaoko, and Tsilikiang, dry Yangtze drainage basin, alt. 14000 ft., *J. F. Rock 9765,* May 1923. (HUN)

Distrib.: Not reported from other provinces in China.

This species is characterized by its elongate and radicant suckers, short raceme with few lower bracteate flowers and glabrous elliptic silicles with curved spreading pedicels.

DRABA MONGOLICA Turcz., Bull. Soc. Nat. Mosc. 15:256. 1842.

Perennial herb, 5-15 cm. high, entirely covered with simple and branched hairs except the corolla and fruit, stem simple and erect; basal leaves long-petioled, elliptic, acute at the apex, tapering toward the base, nearly entire or with 1-3 pointed teeth on each side; cauline leaves small, sessile, subamplexicaul, ovate-oblong, acuminate at the apex, margin often 1-3-denticulate on each side; flowers mostly in terminal racemes, sometimes axillary above the middle of the stem; sepals small, ovate, villous outside, lateral pair somewhat saccate at the base; petals obovate, clawed, double the length of the calyx; stamens 6, filaments slender, about 2 mm. long; pistil elliptic, stigma entire, subsessile; silicle elliptic with acutish ends, about 6 mm. long, 2 mm. broad, compressed; valves glabrous, more or less wrinkled, midrib clear near the base; seeds 2-seriate, more than 10 in number, small, ovoid, brown; fruiting pedicel erect-spreading, hairy, 2-4 mm. long.

Hopei: Hsiao-wu-tai-shan, Y. *Yabe,* July 30, 1906.

Shansi: Wu-tai, Tung-tai, Y. *Yabe,* July 17, 1907.

Szechuan: Omei Hsien, *T. H. Tu 312,* 1936.

Kansu and Tsinghai border: *Y. C. Wu 272.*

Distrib.: Also recorded in Mongolia and Tibet.

This species is characterized by its 1-3-denticulated cauline leaves, elliptic-compressed silicle with acutish ends, glabrous valves with a distinct midrib, and the hairy, 2-4 mm. long fruiting pedicels.

DRABA OREODOXA W. W. Sm., Not. Roy. Bot. Gard. Edinbg. 2:209. 1919.

Small tufted perennial herb, 5-10 cm. high; stem many, base subdecumbent, erect above, with simple, forked and stellate hairs; radical leaves in dense rosettes; cauline leaves 3-5, 10-15 mm. long, 4-5 mm. broad, obovate or spatulate or oblong, apex rounded, base tapering into an indistinct petiole, entire, with minute, simple, forked and stellate hairs, or glabrescent; flowers 10-15 in corymbose raceme, few lower ones bracteate; sepals 2.5 mm. long, outer ones obovate, inner ones ovate, subsaccate, apex rounded, margin pale-yellow, with forked hairs on dorsal side; petals yellow, broadly obovate, emarginate, base shortly clawed, about twice as long as the calyx; stamens 6, about 2.5 mm. long, filaments dilated toward the base; pistil glabrous, ovary ovoid, style short, stigma depressedly capitate; pedicel 5-2 mm. long; examined silicle immature.

Yunnan: Mount Habashan, north of the Likiang Snow Range, Yangtze drainage basin, in limestone gravel, alt. 14000 ft., *J. F. Rock 9703,* July 1923. (HUN)

This species is a small tufted herb with many stems, each of which bearing 3-5 obovate-spatulate leaves, scattered with simple, forked, and stellate hairs, or glabrescent; and with 10-15 flowers in corymbose raceme, few lower ones bracteate.

DRABA YUNNANENSIS Franch., Bull. Soc. Bot. de Fr., 33:402. 1886.

Perennial herb, with many heads, flowering stem 6-15 cm. long; basal leaves in dense rosettes, oblong-obovate, entire, base cuneate, subsessile; cauline leaves 15-20 mm. long, oblong-lanceolate, acutish, entire or slightly denticulate, base slightly amplexicaul; all with simple and forked hairs above and along the margin, stellate hairs below; racemes dense, then elongated, few basal flowers bracteate, pedicels 10-6 mm. long, filiform, with simple and branched hairs; sepals 2.5-3 mm. long, outer ones broadly oblong, obtuse, inner ones ovate, apex rounded, base subsaccate, all with simple and forked hairs on dorsal sides; petals yellow, 4-6 mm. long, lamina obovate, apex emarginate, base cuneate and shortly clawed; stamens 6, 2:3.5 mm. long, anthers oblong, filaments dilated toward the base; pistil flask-shaped, narrow, glabrous, style very short, terminating with a stigmatic end.

Yunnan: Yangtze watershed, western slopes of Likiang Snow Range, *J. F. Rock 4186,* 1922. "Among rocks, alt. 12000 ft." (HUN)

Szechuan: Yungning, on ledges of cliffs and stony pasture, alt. 14,000 ft., *G. Forrest 21229,* June 1922. "Plant of 6-10 inches, flowers bright yellow." (HUN)

Sikang: Mount Siga, northeast of Kulu, alt. 4450 m., *J. F. Rock 17876,* June 1929. "Flowers yellow." (HUN)

This plant is distinguished from its closely related species *D. aprica* O. E. Schulz by its simple stem, 2.5-3 mm. long sepals, and glabrous silicle; while *D. aprica* has a branched stem, 2 mm. long sepals, and pilose silicles.

f. NIVALIS Diels, Not. Roy. Bot. Gard. Edinbg. 31:108. 1912.

Plant small, flowering stem 6-7 cm. high, with 7-9 small linear-lanceolate leaves, 8-10 mm. long, 2-3 mm. broad; basal leaves in dense rosettes, 5-8 mm. long, densely covered with white stellate hairs on both sides and mixed with simple hairs above.

Yunnan: Yangtze watershed, in the Prefectural District of Likiang, eastern slopes of Likiang Snow Range, alt. 11000 ft., *J. F. Rock 3820,* May 1922. (HUN) Yung-peh,

ledges and crevices of dry limestone cliffs, alt. 10,000 ft., G. *Forrest 21150,* Mar. 1922. "Tufted plant of 3-6 in., flowers orange-yellow." (HUN)

var. GRACILIPES Franch., l. c.

Plant many stemed, somewhat flexuose; cauline leaves lanceolate, 14-18 mm. long, 2.5-3 mm. broad; pedicels nearly filiform; silicles often contorted, narrow.

Yunnan: Yangtze watershed, Prefectural District of Likiang, eastern slopes of Likiang Snow Range, *J. F. Rock 3674,* May 1922. "On volcanic rock." (HUN)

var. LATIFOLIA O. E. Schulz, Das Pflanzenr. 4(105):182. 1927.

Basal leaves obovate, cauline leaves elliptic or broadly oblong.

Yunnan: Eastern slopes of Likiang Snow Range, Yangtze watershed, alt. 17,000 ft., *J. F. Rock 9430* (Co-type), July 1923. (HUN)

DRABA SENILIS O. E. Schulz, Notizb. Bot. Gart. Berlin-Dahlem 9:475. 1926.

Little tufted greyish white herb, densely covered with simple, forked and stellate hairs; small branches straw-colored, often decumbent and rooting, lower leaves persistent, scariose, scale-like; upper leaves in rosettes, narrowly obovate, obtusish, entire, with the base tapering into a short petiole, 4-8 mm. long, densely covered with white, forked and stellate hairs below, mostly simple hairs above; scape about 1 cm. long, terminated with 3-5 flowers in umbel-like raceme, flowering pedicel 1.5 mm. long, densely covered with brownish hairs; sepals 2-2.5 mm. long, ovate, apex rounded, pilose on dorsal side; petals yellow, 3-4 mm. long, lamina narrowly obovate, apex rounded, base short, narrowly clawed; stamens 2.8:3 mm. long, filaments dilated toward the base; ovary ovoid, style 0.5 mm. long; silicle ovoid, often subcontorted, with tapering style, 0.75 mm. long.

Yunnan: Yangtze watershed, Prefectural District of Likiang, eastern slopes of Likiang Snow Range, alt. 4000 m., *J. F. Rock 3968* (Co-type), May 1922. "Flowers yellow." (HUN)

Distrib.: Only in type-locality Yunnan, not reported from elsewhere.

This species is closely allied to *D oreades* Schrenk from which it differs in its narrowly obovate leaves, densely covered with greyish white simple, forked and stellate hairs; and a very short scape with brownish elongate hairs.

DRABA INVOLUCRATA W. W. Sm., Not. Roy. Bot. Gard. Edinbg. 11:206. 1919.

D. ALPINA L. var. LEIOPHYLLA Fr., Bull. Soc. Bot. Fr. 30:401. 1886.

D. ALPINA L. var. INVOLUCRATA W. W. Sm., l. c. 8:121. 1913.

Low caespitose herb, branches enwrapped with persistent linear-lanceolate straw-colored leaves; upper ones in rosettes, obovate, rounded at apex, base cuneate and tapering into a short and narrow petiole, 3-8 mm. long, with minutely substellate hairs, glabrescent eventually; scape aphyllous, 0.5-1 cm. long, with short branched hairs; the pedicels 6-3 mm. long, also covered with short branched hairs and terminated with 3-8 flowers in corymbose raceme; sepals 2-2.5 mm. long, outer ones obovate, inner ones ovate, all rounded at the apex, trinerved, pubescent with simple and branched hairs on the dorsal sides; petals yellow, 3-4 mm. long, lamina broadly obovate, apex rounded, subtruncate to emarginate, base shortly clawed; stamens 6, filaments 1.8:2 mm. long, sometimes dilated; ovary ovoid, style very short, stigma depressedly capitate.

Yunnan: Yangtze watershed, Prefectural District of Likiang, eastern slopes of Likiang Snow Range, alt. 16,000 ft., on rocks, *J. F. Rock 5248,* 1922. (HUN)

Distrib.: Not reported in other provinces of China.

This species differs from the others by its minutely substellate pubescent to glabrescent habit and with several flowers in corymbose-raceme, and 6-3 mm. long pedicels.

DRABA LICHIANGENSIS W. W. Sm., Not. Bot. Gard. Edinb. 11:208. 1919.

D. TIBETICA Diels, Not. Bot. Gard. Edinb. 7:104. 1912, non H. f. et T.

Small perennial herb, covered with simple and forked hairs; root woody; stem with many branchlets, 1-2 cm. long, intricate, firm, nigrescent; lower leaves on branchlets linear-lanceolate, persistent, scariose, scale-like, greyish black to straw-colored; upper leaves 4-7 mm. long, 1-2 mm. broad, in dense rosettes, oblanceolate, acute, entire, base tapering into a narrow petiole; scape about 1 cm. long, leafy or leafless, terminated with 5-10 flowers in corymbose raceme, each of the lower 1-5 flowers bracteate; sepals 1-2 mm. long, oblong, obtuse, pilose on the dorsal sides; petals yellowish white, lamina broadly obovate, apex subemarginate, shortly clawed; stamens 6, 1.2:1.5 mm. long; pistil short, flask-shaped; silicle ovoid, acute, glabrous, 3.5-5 mm. long, 1.5-2 mm. broad; fruiting pedicels filiform, obliquely spreading, pubescent, 2-1 mm. long.

Sikang: Mountains between the Litang and Yalung rivers, between Muli Gomba and Baurong and Wa-erh-dje, alt. 4600 m., *J. F. Rock 16709,* July 1928. (HUN)

Distrib.: Also recorded in Yunnan and Szechuan.

This species is recognized by its short corymbose-raceme with few bracteate and somewhat involucrate flowers; and its ovoid glabrous silicle with acute apex, very short style, and subcapitate stigma.

DRABA OREADES Schr. prol. CHINENSIS Schulz, W. Limpr., Bot. Reisen Hochgeb. Chin. Ost.-Tib. in Fedde, Repert. Beih. 12:388. 1922.

Tufted herb, basal leaves rosulate, oblong, petioled, acute-obtuse at apex, cuneate at base, entire or 1-denticulate on each side of ciliated margin, with simple and forked hairs on both surfaces; scape 5-7 cm. long, villous, one-leaved, with umbel-like raceme at tip; sepals nearly elliptic-orbicular, 2 mm. long, 1.5 mm. broad, lateral pair obovate and somewhat saccate, villous outside; petals yellow, obovate, shortly-clawed, emarginate at apex, cuneate toward the base, about 5 mm. long and half as broad; stamens 6, filaments dilated toward the base, 2-2.5 mm. long; pistil ovoid, style ½ mm. long, stigma entire; pedicels 9-5 mm. long, densely villous.

Southwestern Kansu: T'ao River basin, Minshan range, on limestone crags of Mt. Kuangke, alt. 12500 ft., *J. F. Rock 12388,* June 1925. "Flowers yellow."

Distrib.: Also recorded in N. Shensi, Szechuan, Tibet, and Yunnan.

This prole differs from the species by its longer scape which often bears 1-leaf below, and the bigger flowers with pedicels 9-5 mm. long. The pubescence of leaves is densely covered with simple and forked hairs on both sides.

DRABA OREADES Schrenk var. COMMUTATA (E. Regel) O. E. Schulz, Das Pflanzenr. 4(105):109. 1927.

D. PILOSA Adams. γ COMMUTATA E. Regel, Bull. Soc. Nat. Mos. 34(2):185. 1861.

D. GLACIALIS Adams. α TYPICA E. Regel, l. c. 186.

Small tufted herb, forked branched near the base; basal leaves rosulate, narrowly oblong to obovate-cuneate, rounded or acute at apex, tapering toward the base, 4-6 mm. long, margin entire, ciliate, glabrous or with simple and forked hairs on both sides; scape 1-2 cm. long, leafless, villous, with umbel-like raceme at tip; flowers showy, sepals ovate, truncate at the base, lateral pair somewhat saccate, villous outside, 2 mm. long, 1.5 mm. broad; petals yellow, slightly obcordate, shortly clawed, 3.5-4 mm. long, 2 mm. broad; stamens 6, filaments broadly dilated near the base, 1.5-2 mm. long; pistil ovate, style about ½ mm. long, stigma entire; pedicels 3-2 mm. long, densely villous; silicle broadly ovate, compressed, 5-6 mm. long, 2-3 mm. broad, valves glabrous, nerveless.

Eastern Tibet: Alpine region between Radja and Jupar range, Mt. Wotila, alt. 14000 ft., *J. F. Rock 14228*, June 1926. "In muddy gravel; flowers yellow."

Distrib.: Also recorded in Western Mongolia.

This variety is easily recognized by its short scape and a pedicel within 3 mm. in length. Its leaves are covered with simple and forked hairs on both sides or glabrous.

DRABA OREADES Schrenk var. TAFELII O. E. Schulz, Das Pflanzenr. 4(105):108. 1927.

Small tufted herb, basal leaves in closely rosettes, small, spatulate to linear, both sides glabrous, margin entire and ciliate; scape 1-5 cm. long, villous, leafless, with umbel-like raceme at top; flowers small, sepals broadly ovate, truncate at base, villous outside, 2 mm. long, 1.5 mm. broad; petals yellow, narrowly oblong, emarginate at apex, tapering toward the base, 3-3.5 mm. long, 1-1.5 mm. broad; stamens 6, filaments dilated toward the base, 2 mm. long; pistil broadly ovate, style very short, stigma entire; pedicels 6-2 mm. long, densely villous; silicle ovate to broadly ovate, 5-6 mm. long, 2-2.75 mm. wide, compressed, valves glabrous, nerveless.

Eastern Tibet: Alpine region between Radja and Jupar range, *J. F. Rock 14142*, June 1926. "Swampy meadows of Wago-la, north of Radja, alt. 14300 ft."

Distrib.: Not reported elsewhere.

This variety is distinguishable from its allies by its glabrous leaves with ciliate margin, and small flowers with a 6-2 mm. long pedicel.

FLOWERING PLANTS OF NORTHWESTERN CHINA, III.

CHIEN P'EI

ULMACEAE*

There are a few genera of the elm family occurring in northwestern China. *Ulmus pumila* L. is found everywhere in this region, for it is hardy to almost any kind of soil and the people likes to plant it for its quick growth. The species of *Celtis* and *Zelkova* are comparatively scanty in this region. They grow with other trees in

*The descriptions of most of the genera and species are given in Bot. Bull. Acad. Sinica, 1: 283-297, 1947.

forests and thickets. All these genera occur in this region but never in pure stands. The following analytical key gives the differences among these three genera.

1. Flowers on the current year's shoots; fruit a drupe or nutlet .... 2.
1. Flowers on last year's shoots; fruit a samara .... *Ulmus.*
2. Sepals connate; style eccentric; fruit oblique .... *Zelkova.*
2. Sepals distinct or nearly so; style central; fruit globose .... *Celtis.*

ZELKOVA Spach

ZELKOVA SCHNEIDERIANA Hand.-Mazz. Sym. Sin. 7: 104. 1929.

Kansu: Peilung-kiang, *C. K. Chow,* Nov. 1945; Peihsui-kiang, *C. K. Chow,* Oct.-Nov. 1945.

This species is found for the first time in Kansu. There is another species, *Z. sinica* Schneid., found in this region. *Z. Schneideriana* Hand.-Mazz. is easily distinguished from *Z. sinica* Schneid. by its leaves more or less grayish pubescent beneath, by its smaller fruit.

CELTIS Linnaeus

1. New branchlets yellowish-pubescent; leaves ovate, obtuse to shortly acuminate, light yellow beneath, opaque above .... *C. labilis.*
1. New branchlets glabrous; leaves ovate-lanceolate, acuminate, lustrous-green on both surfaces .... *C. Bungeana.*

CELTIS LABILIS Schneider, Sargent's Pl. Wilson. 3: 267. 1916.

CELTIS SINENSIS Hemsl., Jour. Linn. Soc. 26: 450. 1894, quoad Henry's nos. 3403 et 7866, non Persoon.

Trees up to 16 m. high; new branchlets yellowish-pubescent; leaves obliquely ovate to ovate-elliptic, obtuse to slightly acuminate at apex, rounded at base, greenish and opague above, yellowish-green beneath, hispidulous on both surfaces, serrate mostly on one side of the leaf, the other side with a few teeth only, trinerved at base, 3-5.5 cm. long, 1.5-2.5 cm. broad, petioles about 5 mm. long, densely pubescent; fruit small, glabrous, about 7 mm. in diameter, falling off with the pedicel.

Kansu: Hsiolung-shan, *C. H. Hê,* June-Aug. 1945.

Distrib.: Also found in Hopei, Honan, Kiangsu? and Hupeh.

The specimen collected by Mr. Hê has smaller leaves as compared with the specimens from Hupeh, but in other characters they are the same.

CELTIS BUNGEANA Blume, Mus. Bot. Lugd.-Bat. 1: 71. 1852.

Kansu: Peilung-shan, *C. K. Chow 111,* Oct.-Nov. 1945.

This is a common tree in northern China, but also found in Szechuan, Yunnan and Kiangsu. It is easily recognized by its long acuminate and lustrous leaves.

ULMUS Linneaus

1. Branches without corky wings; leaves small, less than 6 cm. long, margin simple toothed... *U. pumila*
1. Branches with corky wings round the whole branch; leaves large, up to 11 cm. long, margin doubly serrate-dentate .... *U. japonica.*

ULMUS PUMILA Linn. Sp. Pl. 226, 1753.

Sinkiang: T'a-cheng, *C. Lin 31, 23* and *83*, "cultivated".

Kansu: Kilien-shan, *C. K. Chow 83* and *143*, July-Aug. 1945.

This elm due to its adaptation to any kind of soil occurs widely in northern China and is also extensively cultivated for its wood.

ULMUS JAPONICA (Rehd.) Sargent, Trees and Shrubs, 2: 1, t. 101. 1907.

Kansu: Hsiolung-shan, Sinkia-shan, *C. H. Hê*, June-Aug. 1945.

This elm is distributed in many provinces of China, but its occurrence is not frequent. The Kansu specimen collected by Mr. Hê has smaller leaves which do not exceed 5.5 cm. in length and are ovate-elliptic in shape.

VERBENACEAE

Herbs, shrubs and tall trees, sometimes scandent; leaves opposite, rarely whorled, simple, digitate or pinnately compound, stipules absent; inflorescence racemose, cymose, spicate or paniculately corymbose, terminal or axillary; flowers usually zygomorphic; calyx persistent, cup-shaped, 4-5-toothed, rarely more; corolla tubular, 4-5-lobed, lobes spreading; stamens 4, didynamous, rarely 5-6, inserted on corolla-tube, anthers 2-celled, longitudinally dehiscent; ovary superior, entire or 4-furrowed, 2-4 rarely 8-celled, 1 ovule in each cell; ovule erect or pendulous; style simple or 2-fid; fruit drupaceous, or capsular, dehiscent or indehiscent, 2-4- rarely 1-seeded; exalbuminous; embryo straight.

80 genera with about 850 species distributed chiefly in tropical and subtropical regions of both hemispheres; 15 genera recorded in China. In our herbarium we have found three genera collected from northern China.

1. Style simple; inflorescence usually adaxil; flowers not 2-lipped . . . . . . *Callicarpa*
1. Style bifid; inflorescence usually terminal or axillary; flowers 2-lipped. . . . . . 2.
2. Fruit with 1 pyrene; leaves digitate . . . . . . *Vitex*.
2. Fruit with 4 pyrenes; leaves simple . . . . . . *Caryopteris*

CALLICARPA Linnaeus

Shrubs, rarely trees, clothed with stellate or farinose tomentotum, shining wax-like glands, rarely glabrous; leaves opposite, rarely ternately whorled, entire to serrulate, rarely lobed; flowers small, white to reddish-purple, sessile or pedunculate, usually of many-flowered cymes, with inconspicuous linear bracts; calyx small, campanulate, truncate or 4-toothed at the apex; corolla small, campanulate or tubular, tube twice as long as the calyx or less, 4-lobed, lobes erect or spreading; stamens 4, equal, inserted on the middle of the corolla-tube, rarely at the base, filaments slender, exserted, anthers ovate or oblong, dorsifixed, glandular; style long, stigma dilated, shortly or obscurely 2-fid; ovary imperfectly 2-celled, with 2-ovules in each cell, ovules attached at the middle; fruit a drupe, globose, with persistent calyx, exocarp thin, mesocarp fleshy, endocarp bony, with 4 or fewer pyrenes; seeds small, oblong, with thin testa, exalbuminous, with fleshy cotyledons.

About 80 species distributed in tropical and subtropical Asia, few in tropical America and Africa. In China there are about 20 species recorded and the following species is solely collected in the northwestern provinces of China.

CALLICARPA BODINIERI Levl. var. GIRALDII (Rehd.) Rehd., Jour. Arn. Arb. 15: 322. 1934.

Callicarpa Giraldii "Hesse" Rehd., Bailey Stand. Cycl. Hort. 3: 629. 1914.

Callicarpa Giraldiana Hort. Hesse apud Schneider, Ill. Handb. Laubholzk. 2: 1048. 1912, nom. nud.

Callicarpa Mairei Levl., Sert. Yunnan, 2. 1916; Cat. Pl. Yunnan, 297. 1917.

Shrubs with densely stellate hairs on young branchlets; leaves ovate-elliptic to elliptic-lanceolate, crenate-serrate, acuminate at apex, cuneate at base, densely glandular-pubescent beneath, sparsely pubescent above or denser on veins; petiole pubescent; flowers pinkish; fruit violet, 2-3 mm. in diameter.

Kansu: Peilung-kiang, *C. K. Chow 82,* Oct.-Nov. 1945.

This species is very common in China occurring from central China southward to Kwangtung and Yunnan. It differs from the type by its larger leaves which are less pubescent on the lower surface.

VITEX Linnaeus

Shrubs or large trees; branchlets densely pubescent, tetragonous; leaves opposite, digitately compound with 3-8-foliolate, rarely unifoliolate, usually with long petioles; leaflets usually entire, dentate, serrate to incised, usually petioluled; inflorescence terminal or axillary, in sessile or peduncled panicles or cymes; bracts caducous, usually very small; flowers bluish, white or yellow; calyx campanulate or tubular, funnel-shaped, usually truncate or shortly 5-toothed, sometimes 2-lipped with 3-5 teeth; corolla small, usually 2-lipped, upper lip 2-lobed, lower one 3-lobed, the median lobe of the lower lip much larger and longer; stamens 4, didynamous, usually exserted, anther-cells various, usually divaricate; ovary 2-4-celled; style filiform, stigma 2-fid; fruit a drupe, globose to obovoid or ovoid, subtended by enlarged calyx; seeds obovate to oblong, exalbuminous.

About 150 species distributed in tropical regions of both hemispheres, a few in temperate regions; in China about 14 species recorded; the following species is commonly found in northwestern China.

VITEX NEGUNDO Linn. var. INCISA (Lam.) Clarke, Hook.f. Fl. Brit. Ind. 4: 584. 1885.

Vitex chinensis Mill. Gard. Dict. ed. 8, no. 5. 1768.

Vitex incisa Lam. Encycl. Meth. 2: 612. 1788.

Low shrubs with tetragonous and densely mealy-white branchlets; leaves 5-foliolate, with 3.5-5 cm. long petiole; leaflets usually ovate-lanceolate, deeply lobed to incised, acuminate at apex, cuneate at base, mealy-white beneath, green to slightly mealy-white above, terminal leaflet the longest, 1.5-8 cm. long, 5 mm. to 3 cm. broad; petiole 1-5 cm. long, mealy-white; inflorescence terminal, spike-like panicle about 10 cm. long; flowers small; calyx 5-toothed, mealy-white outside, with tube 2 mm. in length; corolla-tube slightly longer than the calyx-tube; stamens exserted; fruit ovoid, 1.5 mm. in diameter.

Kansu: Peilung-kiang, *C. K. Chow 5,* Oct.-Nov. 1945.

This variety is widely distributed from Japan southward to India and Java. In China, it occurs commonly in northern provinces.

CARYOPTERIS Bunge

Perennial herbs or shrubs, erect or rambling; leaves opposite, linear to ovate, entire or crenate-serrate, glandular; flowers solitary or in lax to dense cymose panicles; calyx 5-toothed; corolla 4-5-lobed, spreading, 2-lipped, upper lobes equal, lower one concave, much larger, entire, toothed or fimbriate; stamens 4, exserted, inserted on upper part of the corolla-tube; style exserted, 2-fid; ovary 4-celled, with pendulous or laterally attached ovules; fruit dry with 4 1-seeded pyrenes of thin or winged edges.

About 15 species distributed in central and eastern Asia; 12 species recorded in China. There are 2 species commonly growing in northwestern China.

1. Leaves entire, linear, mealy-white beneath .... *C. mongholica*
1. Leaves ovate-oblong, crenate-serrate, tomentose beneath .... *C. tangutica.*

CARYOPTERIS MONGHOLICA Bunge Pl. Mongh. China, 28. 1835.

Low shrubs up to 2 feet high, branchlets reddish brown, puberulous; leaves linear, entire, slightly tapering at both ends, mealy-white and puberulous beneath, dark green and puberulous above, with veins inconspicuous or black in color, 1.5-3 cm. long, about 4 mm. broad, with short petioles about 3 mm. in length; inflorescence cymose, terminal or axillary, with 1.5-2 cm. long peduncle; flowers bluish, with long exserted stamens and fimbriate lower corolla-lobe; fruit glabrous, slightly edged.

Kansu: Kilien-shan, along Heiho, *C. K. Chow 72,* July-Aug. 1945; new record.

This species is easily recognized by its dwarfed habit, mealy-white linear leaves and bright bluish flowers.

CARYOPTERIS TANGUTICA Maxim., Bull. Acad. Sci. St. Petersb. 27: 525. 1881, 31: 87. 1886.

Bushy shrubs up to 3 feet high; branchlets brownish gray; leaves ovate to ovate-oblong, crenate-serrate, tomentose beneath, dark-green and densely puberulous above, 1.5-2.5 cm. long, 6-11 mm. broad, with veins conspicuous beneath and depressed above; petiole pubescent, 4-6 mm. long; cymes axiliary, with pubescent peduncle not exceeding 1 cm. in length; flowers with lower corolla-lobe not strongly fimbriate, corolla-tube twice as long as the calyx-tube; stamens longly exserted; fruit glabrous, slightly edged.

Kansu: Taoho, *C. K. Chow,* June-Sept. 1945; Peilung-kiang, *C. K. Chow 4,* Oct.-Nov. 1945.

The species is distributed southward to Hupeh and western Szechuan. By its habit it is very similar to *Caryopteris incana* (Thunb.) Miq. from which it differs by its glabrous ovary and fruit.

DIPSACACEAE

Hairy or prickly perennial herbs, rarely glabrous; leaves opposite or whorled, exstipulate, entire or dentate, lobed to pinnate, the base sometimes connate; flowers usually dense in heads, surrounded by bracts, or whorled in spikes; bracteoles present as scales on the receptacle; calyx-tube adnate to the ovary, usually constricted above it, limb expanded, cup-shaped or bristle-like; corolla funnel-shaped, limb 2-5-fid, equal or 2-lipped, or in the ray-flowers 2-lipped, disk-flowers equal; stamens 4 or 2, inserted near the throat of the corolla-tube, anthers exserted, linear-oblong; ovary free or adnate to a narrow funnel-shaped or utricular enveloping involucel, 1-celled, with 1 pendulous

ovule, style filiform, stigma capitate, slightly lobed, rarely linear; achene dry, enveloped by the involucel and often adnate to it; usually crowned by the calyx-limb; seed pendulous, albuminous; embryo straight.

7 genera with about 140 species in Europe, Asia and Africa; 4 genera with about 20 species recorded in China.

The specimens collected from northwestern China represent one genus, *Morina,* with two species. The genus, *Pterocephalus,* being of rare occurrence in southwestern China is noteworthy. The differences between these two genera are given in the following key.

1. Flowers whorled on a spike; calyx-tube oblique, with few toothed spines .. ..*Morina*
1. Flowers in heads; calyx-tube cup-shaped, with 10 or more radiate bristles ....*Pterocephalus*

MORINA Linnaeus

Perennial herbs; leaves opposite or whorled, linear to linear-oblong, spinous-toothed, rarely unarmed; flowers whorled, with whorls in spikes or head-like, surrounding by dilate-based floral leaves; bracteoles few among the flowers, spinous; involucel funnel-shaped, spinous, entire or 2-fid; calyx cup-shaped, tube oblique, spinous-toothed; corolla-tube long, funnel-shaped, usually curved, 2-5-lobed, with oblique mouth; stamens 4, inserted near the mouth of the corolla-tube, all fertile, or 2 fertile, with or without 2 rudimentary; style subexserted, with capitate and entire stigma; ovary ovoid, inferior; achene free in the base of the involucel, pericarp usually thickened, wrinkled, apex oblique.

About 12 species distributed in western and central Asia; about 8 species recorded in China. In this herbarium there are two species collected from northwestern China. Their differences are as follows:

1. Leaves sinuate-dentate, spinous; floral spikes elongated ....*M. chinensis*
1. Leaves entire, spinous, floral spikes short nearly head-like ....*M. betonicoides*

MORINA CHINENSIS (Batal.) Diels, Not. Bot. Gard. Edinb. 5: 208? 1912. fig. 1.

Perennial herb up to 60 cm. high; stem simple; leaves 3-4 whorled on each node, connate at base, all linear-oblanceolate, double dentate, all teeth terminated by spines, acute at apex, more or less vaginate at base of the most basal leaves, glabrous, subcoriaceous, 5-15 cm. long, 0.5-1.5 cm. broad, with conspicuous midrib; inflorescence of elongated spike with whorled flowers, about 10 cm. in length; bracts ovate, acuminate, serrate, spinous, about 2.5 cm. long, 8 mm. broad, villose and glandular; involucel funnel-shaped, pubescent, with tube 6 mm. in length, spines about 12 with 2 long ones; calyx funnel-shaped, 2-lipped, tube about 3 mm. long, lips 2-fid with entire lobes, villose within and without; corolla funnel-shaped, tube 5 mm. long, 2-lipped, lower middle lobe 2-fid; stamens 4, with 2 fertile and 2 rudimentary, inserted at the middle of the corolla-tube, anther oblong; style slightly exserted, with entire and head-like stigma; ovary obovoid, slightly scabrid, 2 mm. in length.

Kansu and Tsinghai border: *Y. C. Wu 240.*

Kansu: Tao River basin, in meadows of Maerkku valley, alt. 9500-10000 feet, *Rock 12952,* July 1925, "Spiny herb, flowers greenish".

Szechuan: *F. T. Wang 21424,* 1930.

This species is common in the above regions. Its allied species is *Morina chlorantha*

Diels from which it differs by its sessile leaves and obtuse calyx-lobes.

MORINA BETONICOIDES Benth., Hook. f. Ic. Pl. 12: 63, t. 1171. 1876.

Perennial herbs up to 50 cm. high, glabrous, villose on one line of the stem; leaves glabrous, entire, spinous on margin, basal ones linear-lanceolate, 15-25 cm. long, 1-1.5 cm. broad, cauline ones linear, tapering at the upper part, about 8 cm. long, 1 cm. broad, mid-rib conspicuous, veins parallel, usually 5 in number; flowers whorled in spikes, densely arranged forming head-like; bracts ovate to linear-lanceolate, 2-3.5 cm. long, spinous; involucel-tube about 7 mm. long, equally spinous at the margin; calyx-tube oblique, 5-toothed, teeth terminated by spines; corolla-tube 2 cm. long, curved, 5-lobed, each lobe 2-fid, pubescent outside, glabrous inside; stamens 4, all fertile, inserted at the throat, filaments equal; style with capitate stigma, not exserted; ovary oblong, glabrous.

Kansu: Tao-ho, in meadows in Hsiaoku Gorge, alt. 11500 feet, *Rock 12617,* July 7, 1925, "Herb, flowers whitish green"; Min-shan Range, alt. 1200 feet, *Rock 14611,* Aug. 28, 1926, "Flowers cream colored, bracts spiny, leaf and stem pale green".

This species is distributed from northwestern China southward to Szechuan, Yunnan and India.

PTEROCEPHALUS Adanson

Annual or perennial herbs, undershrubs or shrubs; leaves opposite, usually all basal, entire to pinnatisect or lobed; flowers in terminal heads; bracts leafy, linear or ovate-oblong, bracteoles pilous or bristly; involucel 4-8-ribbed, obscurely dentate, shortly setose, scariose or denticulate-ciliate; calyx with more than 24 bristles, bristles filiform, hairy, rigid; corolla 2-lipped, upper lip short, usually 2-fid, lower lip large, 3-fid; style shortly exserted with slightly lobed and head-like stigma.

About 20 species distributed in Europe and Asia; 3 species recorded in China.

The following species is infrequently found in southwestern China.

PTEROCEPHALUS HOOKERI (Clarke) Höck, Nat. Pflanzenf. 4(4): 189. 1897. Fig. 2.

Scabiosa Hookeri Clarke, Hook. f. Fl. Brit. Ind. 3: 218. 1881.

Pterocephalus batangensis Pax et Hoffm., Fedde Rep. Sp. Nov. Beih. 12: 497. 1922.

Perennial herb with stout woody root, scape up to 35 cm. high; leaves all basal, oblanceolate, tapering at lower part forming a short petiole, base of the petiole dilated, densely hairy on both surfaces, entire or pinnately lobed, obtuse or acute at apex, 4.5-12 cm. long, 0.8-1.6 cm. broad, with leaf-lobes ovate-lanceolate, mid-rib conspicuous; scape simple with one flower head, densely hairy; flower head globose, about 2.5 cm. in diameter; bract ovate-lanceolate, pubescent; bracteoles linear-oblanceolate, about 1 cm. long, pubescent; involucel short, hairy; calyx-bristles filiform, hairy, about 20 in number; corolla 5-lobed, 2-lipped, hairy without, glabrous within; stamens 4, all fertile, inserted at upper part of the corolla-tube, equally exserted; style slightly exserted, with capitate and slightly 3-lobed stigma.

Sikang: Gee-lee-kao, 180 li northwest of Tachienlu, alt. 9000 feet, on cliff, *A. Chen Young 252,* Aug. 4, 1934, "Flowers white, black anthers, fragrant".

This species is also recorded in India. It differs from its related species, *P. Bretschneideri* (Batal.) Pritz., by its greater number of calyx-bristles and by its smaller leaves.

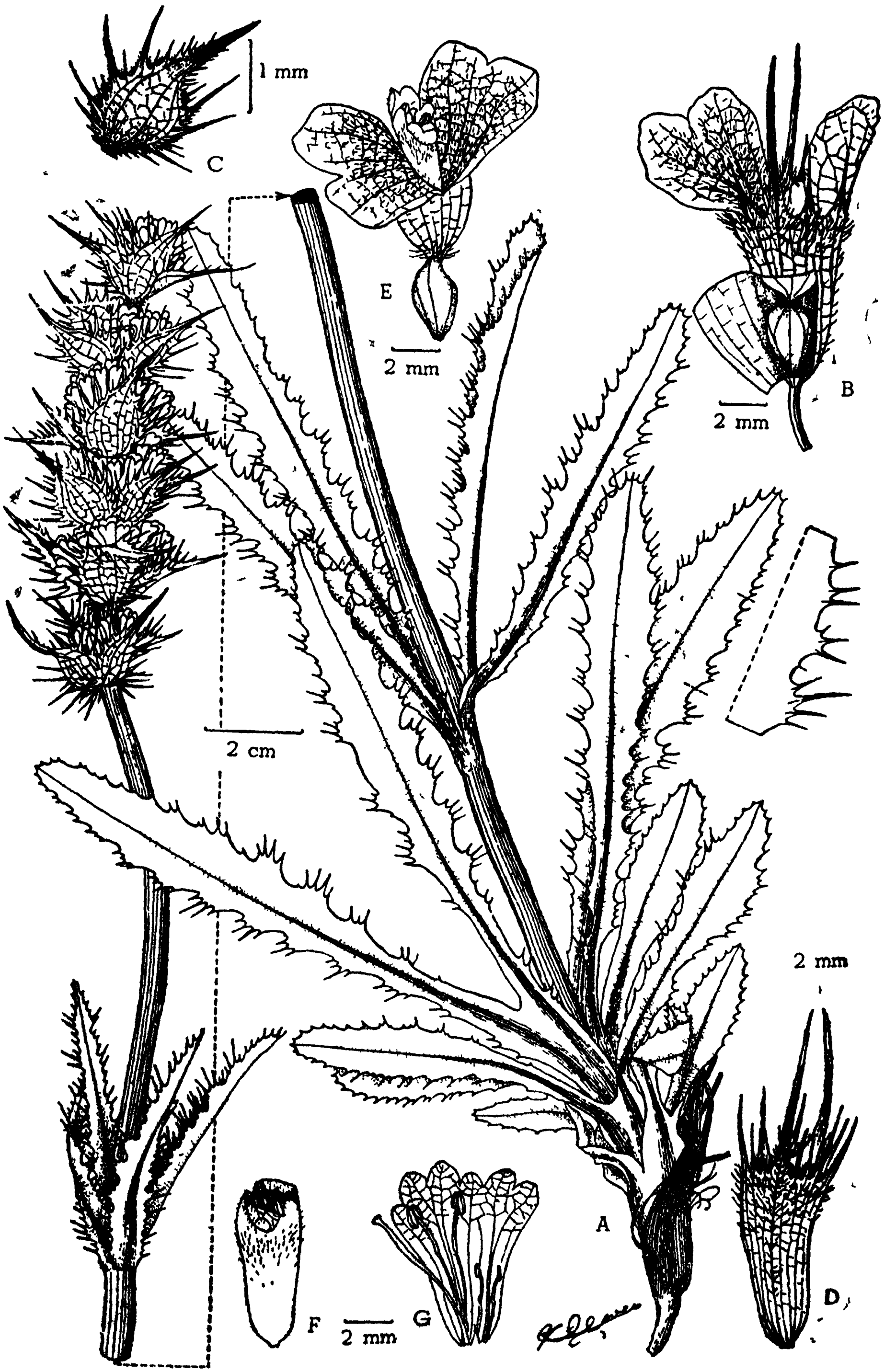

Fig 1. *Morina chinensis* (Batal) Diels: A. Habit, B. Flower; C. Bract; D Involucel; E. Calyx and Corolla; F Flower unopened; G. Corolla dissected, showing position of stamens.

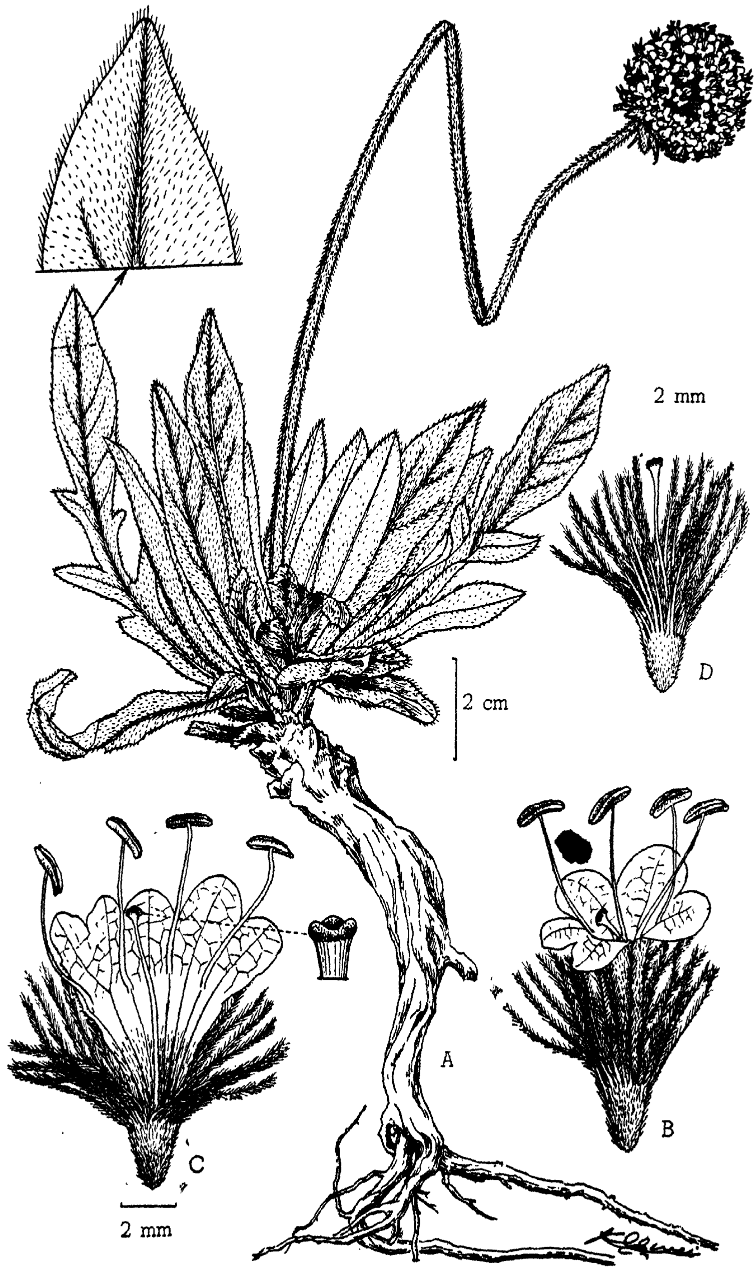

Fig. 2. *Pterocephalus Hookeri* (Clarke) Höck: A. Habit; B. Flower; C. Flower showing the position of stamens; D. Calyx-bristles with style.

STUDIES ON THE FRESHWATER ALGAE OF CHINA. XIX. DESMIDIACEAE FROM KWANGSI.

CHIN-CHIH JAO

INTRODUCTORY REMARKS

In the first volume of the *Bulletin*, the writer began a series of articles on different groups of the freshwater algae collected in the Yangso and Suijen districts, Kwangsi province, south China, during the period from January to July in 1938. Heretofore, three papers on this subject have been published (1: 81—102; 234—254; 257—269, 1947). This is the fourth, in which only the Desmidiaceae are dealt with.

On every collecting trip carried on in the Yangso and Suijen districts, the writer was in full of care in securing the desmids apart from other groups of algae. The total number of the algal samples collected is 201, but only 25 of them contain desmids, yet most of them yield only few species and individuals of this group of algae. This shows that the desmid flora in the Yangso and Suijen districts is scarce and limited in distribution. The fact is that the geological formation of these districts is mostly of limestone in nature, the paucity of the desmids is not to be surprised.

This paper includes 182 species and varieties belonging to 16 genera, viz., 3 *Cylindrocystes*, 1 *Netrium*, 1 *Gonatozygon*, 5 *Penia*, 9 *Closteria*, 11 *Pleurotaenia*, 1 *Triploceras*, 58 *Cosmaria*, 1 *Arthrodesmus*, 7 *Xanthidia*, 43 *Staurastra*, 26 *Euastra*, 11 *Micrasteriae*, 1 *Sphaerozosma*, 3 *Desmidia*, and 1 *Hyalotheca*. If this is a fair sample of the representatives of the Desmidiaceae of the Yangso and Suijen districts, the scarsity or absence of some genera, especially the colonial members, is very striking.

One of the remarkable fact is that the desmids of the Kwangsi province contain a high percentage of tropical elements. There is a number of them which is either described from or commonly distributed in the Indo-Malayan region, including Indo-China Peninsula, Malay Peninsula, Malay Archipelago, India, and Ceylon. These noteworthy members are listed as the follows:

TROPICAL DESMIDS FOUND IN KWANGSI

The members either specially or commonly distributed in the Indo-Malayan region are indicated by an asterisk

*Gonatozygon aculeatum f. Turneri
*Pleurotaenium eletum
*Pleurotaenium eletum var. conjunctum, forma duplo-major
*Pleurotaenium Kayei
*Pleurotaerium ovatum
Pleurotaenium maximum
Pleurotaenium parallelum
Pleurotaenium parallelum var. undulatum
Pleurotaenium Stuhlmannii
Pleurotaenium subundulatum var. corniferum
*Triploceras gracile
*Cosmarium amoenum var. Willei
Cosmarium bireme
*Cosmarium Lundellii var. corruptum
*Cosmarium maculatum
*Cosmarium Malvernianum var. Bedense f. tropica
*Cosmarium Norimbergense
*Cosmarium obsoletum var. dorsitruncatiforme
*Cosmarium obsoletum var. Sitvense
Cosmarium pseudoconnatum
*Xanthidium acanthophorum
*Xanthidium hastiferum var. javanicum
*Xanthidium Freemanii

Xanthidium subtrilobum var. *Kriegerii*
**Staurastrum bifidum* var. *tortum*
**Staurastrum contectum* var. *involutum*
**Staurastrum ensiferum*
Staurastrum excavatum, forma
**Staurastrum indentatum*
**Staurastrum micron*, forma
**Staurastrum pinnatum* var. *subpinnatum*
**Staurastrum quadricornutum* var. *partens*
**Staurastrum retusum*
**Staurastrum retusum* var. *punctatum*
**Staurastrum Sonthalianum*
Staurastrum Tohopekaligense var. *trifurctum*
**Euastrum divergens*
**Euastrum gnathophorum*
**Euastrum quadratum* var. *javanicum*
**Euastrum spicatum* var. *Westii*
Euastrum spinulosum subsp. *africanum*
**Euastrum spinulosum* subsp. *inermius*
**Euastrum strictum*
**Micrasterias alta*
Micrasterias decemdentata
**Micrasterias foliacea*
**Micrasterias Mahobuleshwarensis*
**Micrasterias Moebii* var. *javanica*

According to the above list, there are 48 tropical desmids discovered in the Yangso and Suijen districts, and 37 of them are either the endemic or the common ones recorded from the Indo-Malayan region. As mentioned before, the total number of the desmids listed in this paper is 182; they include at least 40 cosmopolitan and 56 new members. In general, the cosmopolitan ones give no deep meaning in the phytogeographical importance, and the new ones can be look upon as the local forms at the present, but both of them are to be excluded from the total of 182 forms in order to determine the nature of Kwangsi algae. Then we may say that more than half of the remaining members are tropical, and nearly two-fifth are definitely Indo-Malayan forms. These facts indicate that the desmid flora of the Kwangsi province is not only of tropical forms in nature but also definitely of Indo-Malayan in character.

As the Kwangsi province is an entirely unexplored district for the desmid flora, the abundance of new forms is not at all strange. It will be noticed that the type species of a number of the new varieties was described from the Indo-Malayan region, and that of some others from other part of the tropical zone. Of course these varieties can not be considered as the tropical members at the present, but they are in close affinity either with the Indo-Malayan species or with the other tropical forms. The following is a list of all the new species and varieties decribed in this paper.

NEW DESMIDS DESCRIBED IN THIS PAPER

The type species of the new varieties described from the Indo-Malayan region are indicated by an asterisk; those from other part of the tropics by a cross

New Species

Penium terrestre
Closterium amphiceps
Closterium pseudonasutum
Cosmarium cosmstiforme
Cosmarium hexapapillatum
Cosmarium kwangsiense
Cosmarium pseudadoxum
Staurastrum kwangsiense
Staurastrum subapiculiferum
Staurastrum subcyclacanthum
Staurastrum verruciferum
Euastrum subinsulare
Euastrum subpictum
Euastrum subporrectum

New Varieties

Closterium acerosum var. *kwangsiense*
**Closterium nematodes* var. *sinense*
Cosmarium Blyttii var. *basiornatum*
**Cosmarium ceylanicum* var. *sinicum*

Cosmarium creperum var. *sinense*
Cosmarium cyclicum var. *sinense*
Cosmarium distichum var. *suboctogonum*
Cosmarium Garrolense var. *crassum*
Cosmarium granatum var. *mirificum*
Cosmarium granatum var. *subhammeri*
Cosmarium Lundellii var. *pseudotuddalense*
**Cosmarium maculatum* var. *major*
Cosmarium pseudoconnatum var. *subconstrictum*
Cosmarium rectangulare var. *incrassatum*
Cosmarium spyridion var. *subangulatum*
Cosparium subauriculatum var. *kwangsiense*
Cosmarium subspeciosum var. *simplicius*
Cosmarium subtumidum var. *kwangsiense*
Cosmarium umbilicatum var. *glabrum*
Cosmarium rexatum var. *sinense*
**Xanthidium Raciborskii* var. *glabrum*
**Arthrodesmus curvatus* var. *xanthidioides*
Staurastrum aristiferum var. *projectum*
Staurastrum bicoronatum var. *kwangsiense*
Staurastrum contectum var. *quadridentatum*
Staurastrum contectum var. *kwangsiense*
Staurastrum forficulatum var. *ellipticum*
Staurastrum forficulatum var. *simplicius*
Staurastrum longirostratum var. *sinense*
Staurastrum muconatum var. *major*
**Staurastrum mutabile* var. *granulatum*
Staurastrum punctulatum var. *subfusiforme*
Staurastrum punctulatum var. *triangulare*
Staurastrum subcyclacanthum var. *mirificum*
Staurastrum Tohopekaligense var. *quadridentatum*
Euastrum capense var. *orientale*
Euastrum didelta var. *sinicum*
Euastrum dubium var. *kwangsiense*
Euastrum fissum var. *kwangsiense*
Euastrum platycerum var. *ornatum*
**Euastrum plesiocoralloides* var. *sinense*
Euastrum subhypochondrum var. *spicatoides*

Rediscovery of some rare desmids from this province is also highly interesting. These desmids are *Pleurotaenium subundulatun* var. *coroniferum*, *Cosmarium amoenum* var. *Willei*, *C. anisochondrum*, *C. bipunctatum*, *C. contractum* var. *ellipsoideum*, *C. Malivernianum* var. *Badense* f. *tropica*, *C. reniforme* var. *apertum*, *C. Turpinii* var. *eximium*, *Xanthidium antilopaeum* var. *basiornata*, and *X. Freemanii*.

To avoid frequent repitition, a list of the localities in which the desmids were collected is appended; only the corresponding number will be given alone under each species in the systematic portion of this paper:

In the Yangso District

KS11. In rice field, Tung-tao-tsun, Feb. 10.
KS51. In a well connected with slowly flowing springs, in the Yangso city, Feb. 21.
KS64. In a ditch beside the high way, near the Yangso Park, March 23.
KS95. In a pond on a hill, near Tung-tao-tsun, May 2.
KS191. On moist limestone rocks in shade, suburb of the Yangso city, July 5.
KS192. In rice field, suburb of the Yangso city, July 5.
KS194. In rice field, near Tung-tao-tsun, July 17.
KS201. In a pond, suburb of the Yangso city, July 17.

In the Suijen District

KS95. On damp ground in shade, Cha-shan-tsun, May 27.
KS112. In rice field, Shan-kiang-cheih, May 30.
KS119. In rice field, near Sha-kiang-cheih, May 31.
KS137. In rice field, Shan-kiang-cheih, June 1.
KS139. Same as *KS137.*
KS121. In a pond near Huan-shan-tsun, beside Shan-kiang-Cheih, May 31.
KS141. In a pond, near Shan-kiang-cheih, June 3.

KS153. In a small stony pool connected to a slowly flowing spring, Tai-ping-tsun, June 4.

KS157. In a pond, near Chi-cheng-cheih, June 8.

KS179. In a stony pool, near Ta-su-tsun, Lu-pai, June 14.

KS180. In a ditch, near Ta-su-tsun, Lu-pai, June 14.

KS180. In rice field, Chi-cheng-cheih, June 17.

KS184. Same as *KS183.*

KS185 and *KS185: C.* In a shallow pond, near Shiang-tsin-tsun, June 17.

In conclusion, the writer is greatly indebted to Dr. G. W. Prescott for his valuable help in checking up a number of the species listed in this paper.

SYSTEMATIC ENUMERATION OF THE SPECIES OBSERVED

CYLINDROCYSTIS Menegh.

CYLINDROCYSTIS BREBISSONII Menegh. var. MINOR W. et G. S. West, Trans. Roy Irish Acad. 32: 20, pl. 2, fig. 7. 1902.

Long. cell. 28—37 μ lat. 12.5—13.5 μ.

KS95, fairly common, scattered among *Aneura* sp.

This variety has not previously been recorded from China.

CYLINDROCYSTIS BREBISSONII Menegh. var. TURGIDA Schmidle, Österr. bot. Zeitschr. 1895: 309, pl. 14, fig. 15. 1896.

Long. cell. 64—75 μ, lat. 30—31 μ.

KS185: C, scarce.

The measurements of the cells of this variety given by Schmidle are only 24—25 μ, in diameter and 30—47 μ long (loc. cit.), but some later workers found that its cells may be as long as 87 μ and as broad as 75 μ. The cell dimentions of the Chinese plant are also not quite typical.

CYLINDROCYSTIS CRASSA De Bary, 1858; W. and G. S. West, Monogr. Brit. Desm. 1: 59, pl. 4, figs. 33—38. 1904.

Long. cell. 34—36 μ, lat. 17—18 μ.

KS51, Scarce.

This species differs from *C. Brebissonii* Menegh. in having proportionally shorter cells and slightly convex sides,

NETRIUM Naeg.

NETRIUM DIGITUS (Ehr.) Itzigs. et Rothe *in* Rabenh., 1856; W. and G. S. West, Monogr. Brit. Desm. 1: 64, pl. 6, figs. 14—16. 1904.

Long. cell. 206—333 μ, lat. med. 63—65 μ; lat. apic. circ. 20—25

KS11, KS112, and *KS119,* fairly common.

GONATOZYGON De Bary

GONATOZYGON ACULEATUM Hastings f. TURNERI Schmidle, Engl. Bot. Jahrb. 32: 76, pl. 3, fig. 1. 1902.

Gonatozygon pilosum Wolle f. *minor* et *evoluta* Turner, Kgl. Sv. Vet.-Akad. Handl. 25: 25, pl. 20, forma a, fig. 1; forma b, fig. 2. 1892.

Long. cell. 160—170 μ, lat. 11—12 μ; lat. apic. 13—14 μ; long. spin. 6—7 μ.

KS185: C, scarce.

This species and form are distinguished from the nearest species *G. pilosum* Wolle by their characteristic cell wall densely clothed with long and sharp spines.

This form has previously been recorded only from East India and Nyassa.

PENIUM De Bréb.

PENIUM LEBELLULA (Focke) Nordst., Vid. Meddl. nat. Foren. 1888: 184. 1888.

Long. cell. 238—257 μ, lat. 34—38 μ.

KS75 and *KS137,* fairly common.

PENIUM LEBELLULA (Forcke) Nordst. var. INTERRUPTUM W. et G. S. West, Journ. Roy. Micros. Soc. 1897: 479. 1897; Monogr. Brit. Desm. 1: 74, pl. 7, figs. 9, 10. 1904.

Long. cell. 220—250 μ, lat. 35—36 μ.

KS75, fairly rare.

Each segment of the chloroplasts of this variety has ten longitudinal ridges and contains two or three pyrenoids.

This variety has not previously been recorded from China.

PENIUM MARGARITACEUM (Ehr.) Bréb. *in* Ralfs, Brit. Desm. 149, pl. 25, fig. 1 a—c; pl. 33, fig. 3. 1848.

Long. cell. 108—153 μ, lat. 16—17 μ.

KS76, KS179, KS184, and *KS201,* rare in all samples.

In the Chinese plant, the granules on the cell wall are not regularly arranged into longitudinal rows.

PENIUM SPINOSPERMUM Josh., Journ. Bot. 23: 23, pl. 254, fig. 10. 1885; W. and G. S. West, Monogr. Brit. Desm. 1: 78, pl. 8. figs. 6, 7. 1904. (Fig. 1, *15*)

Forma cellulis diametro circiter 1½-plo longioribus, medio levissime constrictis, utroque polo rotundato-truncatis, lateribus semicellularum subrectis leviter convergentibus. Long. cell. 32.5 μ, lat. 13.5 μ.

KS185: C, rare.

As described by Joshua (loc. cit.), the cell of this species is marked "with a very slight median constriction", however, W. and G. S. West state that the cells are "unconstricted or with a very slight median constriction" (loc. cit.). Both Jashua and Wests describe the apices of the cells as rounded. In the Chinese plant, the cells are constantly showing a very slight but distinct median constriction and have rotundate-truncate apices. These features are, however, not typical.

PENIUM TERRESTRE, sp. nov. (Fig. 1, *16—22*)

P. parvum, subcylindricum vel subobovoideo-cylindricum, duplo et ultra longius quam latum, medio leviter constrictum, utroque polo rotundatum; membrana laevi, achroa; apice semicellularum medio leviter incrassata; pyrenoidibus in utraque semicellula singulis magnisque; zygosporis aspectu fronte subrectangularibus, angulis rotundatis,

lateribus leviter concavis vel subrectis, aspectu laterali subobovoideis, aspectu polari subcircularibus, membrana crassissima, distincte lamellosa, fuscescente, irregulariter verrucosa, verrucis hemisphaericis cavisque. Long. cell. 28—33 μ, lat. 15—16 μ; lat. isthm. 13.5 μ; long. zygosp. 27.5—31.5 μ, lat. 20—29 μ, crass. 18—24.5 μ; crass. membr. zygosp. 3.5—6.5 μ.

KS191, commonly scattered among *Schizothrix chalybea* (Kuetz.) Gom.

This species should be compared with *P. phymatosporum* Nordst., but differs from the latter in having smooth cell wall and different structure of the zygospores. It should also be compared with *P. curtum* Bréb., which occurs especially with *Sphagnum* and wet mosses on rocks. It is clearly distinguished from the latter by its semicells not distinctly attenuated toward the apex and its smooth cell wall. Furthermore, the longitudinal ridges of the chloroplasts are about eight in *P. curtum*, but there are only four or five in the new species.

CLOSTERIUM Nitzsch.

CLOSTERIUM ACEROSUM (Schr.) Ehr. var. KWANGSIENSE, var. nov. (Fig. 1, *14*)

Var. cellulis majoribus, membrana semper hyalina laevique; pyrenoidibus in utraque semicellula 9—18. Long. cell. 698—836 μ, lat. 43—58 μ; lat. apic. 5—7 μ.

KS64, common.

This variety should be compared with *Closterium acerosum* var. *elongatum* Bréb. and var. *angolense* W. et G. S. West, but differs from the first in having colorless and smooth cell wall and from the second in having wider diameter and greater length in the cells and the lateral margins of the cells not parallel but straight for a long distance in the middle of the cell.

CLOSTERIUM AMPHICEPS, sp. nov. (Fig. 1, *9* & *10*)

C. magnum, cellulis diametro circiter 13-plo longioribus, levissime curvatis, ad apices versus gradatim attenuatis dein abrupte constrictis, apicibus distincte dilatatis et oblique rotundatis; membrana luteolo-fuscescente et dense striata, striis 9—10 in 10 μ, ad apices celllullae plerumque anastomosantibus, inter se costulis subtitlibus sed distinctis transversalibus conjunctis, in medio cellulae suturis transversalibus 3—5 instructa, in extrematis cellulae valde incrassata; pyrenoidibus in utraque semicellula 8—10, in serie unica axili dispositis; locellis apicalibus terminalibus et corpusculis numerosis includentibus. Long. cell. 831—840 μ, lat. 64—65 μ; lat. apic. 23—24 μ.

KS185: C, scarce.

This species is characterized by its distinctly inflated apices, its longitudinal striations connected by transverse lines, and its large size, thus it differs from all previously described species of this genus.

CLOSTERIUM INTERMEDIUM Ralfs, Brit. Desm. 171, pl. 29, fig. 3 and fig. 2h. 1848.

Forma cellulis medio rectis, striis 15—16 ornatis. Long. cell. 385—390 μ, lat. 29—30 μ; lat. apic. 13—14 μ.

KS112, fairly rare.

The Chinese plant agrees in the general shape of the cells with *C. intermedium* Ralfs var. *hibernicum* West, but the latter is smaller and has only nine visible striae

across the cell.

CLOSTERIUM LEIBLEINII Kuetz., 1834; W. and G. S. West, Monogr. Brit. Desm. 1: 141, pl. 16, figs. 9—14. 1904.

Lat. cell. 21—25 μ; dist. inter apic. 125 μ. Pyrenoidibus in utraque semicellula plerumque 2, raro 3.

KS76, scarce; *KS201*, common; *KS184*, scarce.

CLOSTERIUM NEMATODES Jashua var. SINENSE, var. nov. (Fig. 1, *13*)

Var. cellulis duplo-minoribus, diametro 9.5-plo longioribus, membrana striis visis 10 ornata; pyrenoidibus in utraque semicellula 3—4. Lat. cell. 12.5—13.5 μ; dist. inter apic. 90—92 μ; lat. ad inflat. apic. 4—5 μ.

KS185: C, scarce.

Closterium nematodes seems to be closely related to *C. lagoense* Nordst., but the first is specially characterized by the fact that the dilated portion below the apex of each simecell is a suddenly thickened node on both sides of the cell wall. This character is not only shown clearly in its typical form, but also in its previously described varieties. On the other hand, the dilated portion in *C. lagoense* is not a thickened node of the cell wall. According to this difference, the writer's specimen is undoubtedly a variety of *C. nematodes*.

CLOSTERIUM PRITCHARDIANUM Arch., Descript. new Cosm. etc., 250, pl. 12, figs. 25—27. 1862.

Long. cell. 520 μ, lat. 43 μ; lat. apic. 6.5 μ.

KS76, rather rare.

CLOSTERIUM PSEUDONASUTUM, sp. nov. (Fig 1, *11* & *12*)

C. submagnum, cellulis diametro circiter 11-plo longioribus, subcylindricis, levissime curvatis, ad apices versus gradatim et levissime attenuatis, sub apicibus truncatis abrupte constrictis; membrana hyalina, distincte striata, striis visis circ. 20, in medio cellulae suturis 2—4 instructa, in extrematis cellulae incrassata; pyrenoidibus in utraque semicellula 12, in serie unica axili dispositis; locellis apicalibus terminalibus et corpusculis numeross includentibus. Long. cell. 474—480 μ, lat. 43—46 μ; lat. apic. circ. 9 μ.

KS201, fairly rare.

This species should be compared with *C. nasutum* Wolle and *C. spetsbergense* Borge. It differs from them chiefly in having proportionally longer and subcylindrical cells with a constantly striated wall. As described by Borge (Ark. f. Bot. 19: 16. 1925), the pyrenoids of *C. nasutum* are small, numerous, and scattered in the chloroplasts. In the Chinese species, they are, however, only 12 in number and arranged in a single row. In 1918, Borge described a large form of *C. nasutum* (Ark. f. Bot. 15: 14. 1918) which has a densely and very finely striated wall. However, the cell wall of the typical form of *C. nasutum* is not in such a structure.

CLOSTERIUM STRIOLATUM Ehr., 1832; W. and G. S. West, Monogr. Brit. Desm. 1: 122, pl. 13, figs. 7—16. 1904.

Long. cell. 275 μ, lat. max. 25 μ; lat. apic. 11 μ.

KS119, rather rare.

CLOSTERIUM VENUS Kuetz., Phyc. germ. 130. 1945.
Lat. cell. 8—12.5 μ; dist. inter apic. 65—95 μ.
KS76, common; *KS184,* rare; *KS201,* common.

PLEUROTAENIUM Naeg.

PLEUROTAENIUM CORONATUM (Bréb.) Rabenh. var. NODULOSUM (Bréb.) West, Journ. Linn. Soc. Bot. 29: 119. 1892; W. and G. S. West, Monogr. Brit. Desm. 1: 200, pl. 28, figs. 5—8. 1904. (Fig. 1, *3*).

Forma cellulis angustioribus. Long. cell. 340—345 μ; lat. ad inflat. basal. semicell. 35—38 μ, ad apic. 23—24 μ.
KS112, rare.

PLEUROTAENIUM ELATUM (Turn.) Borge, Boh. till K. Sv. Vet.-Akad. Handl. 24 16. 1899. (Fig. 1, *1*)
Docidium elatum Turn., K. Sv. Vet.-Akad. Handl. 25: 27, pl. 2, fig. 16. 1893.
Docidium rabustum Turn., loc. cit. 27, pl. 2, fig. 8.

Forma tuberculis apicalibus visis 12; membrana distincte punctata. Long. cell. 423—438 μ; lat. ad inflat. basal. semicell. 30—31.5 μ, ad med. 25—26 μ, ad apic. 27—31.5 μ.
KS141, scarce.

PLEUROTAENIUM ELATUM (Turn.) Borge var. CONJUNCTUM W. et G. S. West f. DUPLO-MAJOR W. et G. S. West, Trans. Linn. Soc. London, Ser. 2, Bot., 6: 144, pl. 18, figs. 29—32. 1902.

Long. cell. 620—750 μ; lat. ad inflat. basal. semicell. 55—72 μ, ad med. 42—67 μ. ad apic. 47—57 μ.
KS119, common.

PLEUROTAENIUM KAYEI Rabenh., Fl. Eur. Alg., 3: 439. 1868; W. and G. S. West, Trans. Linn. Soc. London, Ser. 2, Bot., 6: 141, pl. 18, figs. 33, 34. 1902. (Fig. 1, *7*)
Docidium Kayei Arch., Quart. Journ. Micr. Sci. 1865: 296, pl. 7, fig. 2. 1865.
Docidium horridum Borge, Bih. till K. Sv. Vet.-Akad. Handl., 22: 28, pl. 4, fig. 55. 1896.

Long. cell. 206—276 μ; lat. ad inflat. basal. semicell. sine spin. 45—50 μ, cum spin. 62—68 μ, ad apic. sine spin. 32—38 μ, cum spin. 46—49 μ.
KS75, fairly scarce.

Regarding to the type and number of the spines of this species on the nodes of its semicells, Wests noted that "the conical spines being arranged in pairs. The number of pairs of spines in each whorl varies considerably. Mr. Kaye informed Archer that there were 10 prominences in each whorl; Borge says 15—17 pairs of spines at the base, and 7—12 spines at the apex for his *Docidium horridum.* We find 12 in each whorl, including the apex" (loc. cit. 142). In the Chinese plant, the two spines of each pair are connected at their bases by a prominent rib. Thus, each pair of spines may be considered as a bidentate prominence and is not two isolated conical spines arranged in a pair. The prominence are not always bidentate; they may be sometimes, however, tridentate or unidentate. Furthermore, the prominences on each node are varying in number. There are mostly 12, but sometimes there may be 13 to 15. These

facts do not agree with Wests' note; but are identical to those described and figured by Borge in his *Docidium horridum* (loc. cit.) and also to those described and figured by Gutwinski in a Javanese form of *Pleurotaenium Kayei* (Bull. Acad. Sci. Gracovie 1902: 587, pl. 37, fig. 25. 1902).

Type locality of this species is Hong Kong. It has not previously been recorded from China proper since Archer first described it in 1865.

PLEUROTAENIUM MAXIMUM (Reinsch) Lund., Nov. Act. Soc. Sci. Upsala, 8: 89. 1871.

Docidium maximum Reinsch, Abhandl, Senckenb. Naturforsch. Gesellsch., 4: 140, pl. 27, figs. 1, 2. 1867.

Long. cell. 591—715 μ; lat. ad inflat. basal. semicell. 45—48 μ, ad med. 41—45 μ. ad apic. 28—30 μ.

KS121, rare; *KS180,* rare.

PLEUROTAENIUM OVATUM Nordst., Öfvers. K. Vet.-Akad. Förhandl., 1877: 18. 1877. (Fig. 1, *8*)

Docidium ovatum Nordst., Vid. Medd. Nat. Foren. Kjobenhavn, 1869: 205, pl. 3, fig. 37. 1870.

Long. cell. 312—254 μ; lat. max. semicell. 102—123 μ, ad apic. 37—40 μ; lat. isthm. 60—67 μ.

KS119, common; *KS185:* C, scarce.

This species has not previously been recorded from China. In 1939, Dr. L. C. Li reported a variety of this species, var. *laeve* Bern, from Yunnan.

PLEUROTAENIUM PARALLELUM W. et G. S. West, Trans. Linn. Soc. London, Ser. 2, Bot., 5: 45, pl. 5, fig. 34. 1895.

Forma major, cellulis diametro circiter 16-plo longioribus. Long. cell. 714—900 μ; lat. ad inflat. basal. semicell. 56—60 μ, ad med. 50—60 μ, ad apic. 41—47 μ.

KS119, rather rare.

This species differs from *P. eugeneum* in having truncate apices with 26 tubercles, irregularly and minutely punctate wall, and nearly entirely parallel lateral margins. The present plant shows these characteristics very well, but its dimensions of the cells are greater than those of the typical form of *P. parallelum*.

PLEUROTAENIUM PARALLELUM W. et G. S. West var. UNDULATUM Borge, Ark. f. Bot. 1: 82, pl. 2, fig. 2. 1903.

Two forms were obtained:

Forma A. (Fig. 1, *4*) Cellulis diametro circiter 18-plo longioribus; semicellulis levissime attenuatis apicem versus, lateribus 19-undulatis, apice truncatis, tuberculis ellipticis visis 12; membrana punctata. Long. cell. 800—826 μ, lat. ad inflat. basal. semicell. 45 μ, ad med. 42 μ, ad apic. 40 μ.

KS137, scarce.

Forma B. (Fig. 1, *5*) Cellulis majoribus quam in forma typica, undulationibus supra inflationem basalem indistinctis; membrana punctata. Long. cell. 1010—1070 μ, lat. ad inflat. basal. semicell. 58—63 μ, ad med. 50 μ, ad apic. 40—45 μ.

KS141, fairly scarce.

This variety has the truncate apices and the nearly entirely parallel margins. These features indicate that it is rather closely allied to *P. parallelum* than to *P. eugeneum*

(Turn.) W. et G. S. West. Furthermore, a typical form of *P. parallelum* has also the more or less distinct undulations above the basal inflation of the semicells. These indistinct undulations may be considered as the primitive forms of the variety ***undulatum*** with conspicuous undulations.

The present forms differ from the typical form of the variety ***undulatum*** chiefly in having only 19 undulations (inclusive the basal inflation) and 26 apical tubercles.

Secretion of mucilage at the pores in the cell wall is common in the Chinese forms.

This variety has not previously been recorded from China.

PLEUROTAENIUM STUHLMANNII (Hieron) Schmidle, Engl. Bot. Jahrb., 26: 23, pl. 1, figs. 21, 22. 1898. (Fig. 1, 2)

Docidium Stuhlmannii Hieron, Engl. Pflanzenw. Ost.-Afr. C: 19. 1895.

Cellulis diametro 13—15-plo longioribus, apicibus tuberculis 32—34 instructis; membrana laevi. Long. cell. 680—928 μ; lat. ad inflat. basal. semicell. 60—67 μ, ad mad. 55—62 μ, ad apic. 47—52 μ.

KS137, rare; *KS183* and *KS184*, scarce.

Judging from the drawings of this species given by Schmidle (loc. cit.), the semicells are distinctly but slightly inflated at their middle portion. This character does not show distinctly in the Chinese plant. As described by Schmidle, the cell wall of this species is "minute tuberculato-punctata, interdum laevi". The cell wall of the Chinese species is, however, entirely smooth.

The present form should be compared with *P. cylindricum* (Turn.) W. et G. S. West, but the latter has small size of cells and the semicells are not widened at their middle portion and slightly dilated at their apex.

This species has not previously been recorded from China.

PLEUROTAENIUM SUBUNDULATUM Borge var. CORONIFERUM Borge, Ark. f. Bot. 1: 84, pl. 2, fig. 9. 1903. (Fig. 1, 6)

Long. cell. 335 μ; lat. ad inflat. basal. semicell. 34—35 μ, ad med. 33—34 μ, ad apic. 24—25 μ; lat. isthm. 24 μ.

KS141, rare.

This variety and the species are known to be rare and has not previously been recorded from China.

PLEUROTAENIUM TRABECULA (Ehr.) Naeg., Gatt. einzell. Algar. 104, pl. 6, fig. A. 1849.

Long. cell. 365—490 μ; lat. ad inflat. basal. semicell. 25—33 μ, ad apic. 18—23 μ.

KS75, common; *KS76*, fairly common; *KS119*, *KS137*, and *KS141*, fairly common; *KS180*, rather rare; *KS183* and *KS184*, scarce; *KS185*, rare.

TRIPLOCERAS Bail.

TRIPLOCERAS GRACILE Bail., 1851; Nordst., K. Sv. Vet.-Akad. Handl. 22: 64, pl. 7, fig. 12. 1888.

Long cell. cum acul. 345—434 μ, sine acul. 335—420 μ; lat. ad bas. semicell. cum acul. 32—36 μ, sine acul. 20—23, ad apic. 18—22 μ.

KS185: C, fairly common.

COSMARIUM Corda

COSMARIUM ABBREVIATUM Racib., Pam. Wydz. Akad. Umiej. Krakow. 10: 83, pl. 10, fig. 13. 1885; W. and G. S. West, Monogr. Brit. Desm. 3: 84, pl. 72, figs. 9—11. 1908, Long. cell. 14—15 μ, lat. 13—14 μ, crass. 9 μ; lat. isthm. 6.3 μ.

KS75, rare.

In China, only a form of this species, f. *minor* W. et G. S. West, has previously been recorded from Hunan.

COSMARIUM AMOENUM Bréb. var. WILLEI (Turn.) nob. (Fig. 2, *3*)

Dysphinctum Willei Turn., K. Sv. Vet.-Akad. Handl. 25: 42, pl. 8, fig. 40. 1892.

Var. semicellulis a fronte visis angustioribus quam in forma typica, granulis in seriebus verticalibus 10—11 ordinatis; a latere visis cylindrico-semioblongis; a vertice visis late ellipticis, area centrali glabra; pyrenoidibus binis. Long. cell. 60—68 μ, lat. 29—33 μ, crass. 27—29 μ; lat. isthm. 19—22 μ.

KS141, rare; *KS185: C,* rare.

This is one of those little known desmids. It has previously been recorded only from Bangal, India.

"*Dysphinctum Willei*" was incompletely described by Turner (loc. cit.). He did not give the description and drawing of the cells in its lateral view and the number of pyrenoids in each semicell. Regarding to the vertical view of the cells, he only stated that it is "ovale" in shape, but no drawing and measurements are given by him. Judging from the known characteristics of his species, it differs from *C. amoenum* Bréb. only in having proportionally narrower semicells with the more distinctly arranged vertical and transverse rows of granules. In such a case, it may be better regarded as a variety of *C. amoenum.*

This Chinese alga is almost entirely similar to Turner's "*Dysphinctum Willei*" in all respects excepting that some characteristics given in the above diagnosis are wanting in the original description of Turner's species.

In the front or lateral view, the variety looks somewhat like *C. elegantissimum* Lund. and its variety *simplicius* W. et G. S. West, from which it differs chiefly in having semicells being widely elliptical in its vertical view. *C. elegantissimum* var. *simplicius* f. *major* Fritsch et Rich, an african form, seems to be very closely allied to this variety, but the semicells of the first in the lateral view are only a little narrower than in the front view.

This variety should also be compared with *C. pseudamoenum* Wille, in which the granules are not distinctly arranged in vertical rows and each semicell provides only a single pyrenoid. However, *C. pseudamoenum* is very closely allied to *C. amoenum,* and might probably be better also considered as a variety of the latter.

COSMARIUM ANISOCHONDRUM Nordst., Alg. aq. dulc. et Char. Sandvic. 12, pl. 2, fig. 7. 1879; W. and G. S. West, Monogr. Brit. Desm. 3: 212, pl. 85, fig. 5. 1908. (Fig. 2, *8*) Long. cell. 31.5 μ, lat. 28.8 μ, crass. 19.8 μ; lat. isthm. 8 μ.

KS185: C, rare.

In Wests' Monograph (loc. cit.), the isthmus of this species is 5.3 μ in breadth; according to Nordstedt's original diagnosis (loc. cit.), it is 9.5 μ broad. The breadth

of the isthmus of the Chinese plant is nearest to Nordstedt's measurement. Furthermore, the Chinese plant has three or sometimes four series of minute granules within each lateral margin of the semicells. This feature is not quite identical with West's description and both Wests and Nordstedt's drawings.

In the Chinese plant, the large granules in the central area of the semicells are yellowish in colour. The chloroplast is axial and contains only a single pyrenoid.

This species has previously been recorded only from few localities in Europe and North America.

COSMARIUM BIPUNCTATUM Börg., Vidensk. Medd. naturh. Foren. Kjöbenhavn 1890: 40, pl. 4, fig. 33. 1890. (Fig. 2, *7*)

Forma paullo minor; semicellulis a fronte visis truncato-semicircularibus, granulis minutis in seriebus concentrice ordinatis 3—4 intra marginem instructis. Long. cell. 18 μ, lat. 16.2—17 μ, crass. 11.5—12.6 μ; lat. isthm. 5.4 μ.

KS75, rare.

This alga should be compared with *C. haaboeliense* Wille and its var. *protractum* W. et G. S. West, but differs from them collectively in having smaller cells (cells longer than broad) and two large granules in the centre of the semicells.

This species has not previously been recorded from China.

COSMARIUM BIREME Nordst., Vidensk. Medd. naturh. Foren. Kjöbenhavn, 1869: 212, pl. 3, fig. 33. 1869. (Fig. 1, *39*)

Forma paullo major, papilla centrali crassiore cum apice oblique truncato. Long. cell. 17 μ, lat. 16.2 μ, crass. cum papill. 13.5 μ, sine papill. 9 μ; lat. isthm. 4.5 μ.

KS185: C, rare.

In size, the Chinese plant is nearest to *C. bireme* var. *crassum* W. et G. S. West, but differs from the latter in having smooth cell wall and different shape of the semicells.

COSMARIUM BLYTTII Wille, Christiania Vid.-Selsk. Forhandl. 1880: 25, pl. 1, fig. 26. 1880.

Long. cell. 14.5—15.5 μ, lat. 13.5 μ, crass. 10 μ; lat. isthm. 4.5 μ.

KS76, rare; *KS157,* rather common; *KS192,* rare.

COSMARIUM BLYTTII Wille var. BASIORNATUM, var. nov. (Fig. 2, *15*)

Var. semicellulis supra et juxta isthmum (ad basin semicellularum) una serie horizontali granulorum 4 ornatis. Long. cell. 19 μ, lat. 16.2 μ, crass. 11.7 μ; lat. isthm. 5.4 μ.

KS185: C, scarce.

This variety should be compared with *C. Blyttii* var. *Sovae-Sylvae* W. et G. S. West which also has four granules below the central subpapillate granules. In the new variety the four granules are arranged into a straight row and situated just above the isthmus. In the var. *Sovae-Sylvae,* they are, however, arranged into an arc and placed near the central granule. The lateral crenations of the semicells of the var. *Sovae-Sylvae* are truncate; those in the new variety is, however, distinctly retuse.

COSMARIUM CEYLANICUM W. et G. S. West var. SINICUM, var. nov. (Fig. 2, *11* & *12*)

Var. semicellulis angulis inferioribus superioribusque denticulatis, lateribus 4-undulato-denticulatis, intra marginem lateralem dentibus 4—5 ornatis, dentibus omnibus

similibus breviter et obtuse conicis, apicibus leviter convexis et plus minusve distincte 4-undulatis, granulis infra et juxta marginem apicalem emerginatis et supra contro semicellularum verrucis magnis depresso-hemisphaericis 3 et infra centro verrucis minoribus 2, in centro scrobiculis 6—7 in seriebus 2 vel plus minusve irregulariter ordinatis ornatis; zygosporis globosis, longe spinosis, spinis apice furcatis, base bullatis. Long. cell. 38—39 μ, lat. 29 μ, crass. 21.6 μ; lat. isthm. 8.1 μ; diam. zygospor. sine spin. 32.5 μ, cum spin. 47.5 μ; long. spin zygospor. 6—9 μ.

KS192, rare.

This alga is undoubtedly a variety of *C. ceylanicum,* but it differs from it in quite different ornamentations.

COSMARIUM CIRCULARE Reinsch, Spec. Gen. Alg. 113, pl. 22, CI, figs. 1—4. 1867; W. and G. S. West, Monogr. Brit. Dems. 2: 136, pl. 56, figs. 11, 13, and 14. 1905.

Long. cell. 72.5 μ, lat. 70 μ, crass. 40 μ; isthm. 32.5 μ.

KS119, rare common.

The apex of the semicells of the Chinese plant is subtruncate and agrees in form with that shown in Wests' Monograph plate 56, figure 13.

COSMARIUM CONTRACTUM Kirchn. var. ELLIPSOIDEUM. (Elfv.) W. et G. S. West f. RETUSA W. et G. S. West, Trans. Roy. Irish Acad. 32: 40, pl. 2, fig. 10. 1902. (Fig. 1, *31*)

Forma apice semicellularum levisssime retuso et incrassato; membrana glabra. Long. cell. 36 μ, lat. 27 μ, crass. 20 μ; lat. isthm. 7.2 μ.

KS192, scarce.

As described by W. and G. S. West in their Monogr. Brit. Desm. (2: 173. 1905), this form "in which the cells are slightly retuse in the middle of each apex; cell-wall delicately punctate; length 32 μ; breadth 27.5 μ; breadth of isthmus 5.5 μ". The Chinese plant agrees very well in these respects, excepting that its wall is smooth and thickened at the middle of the apex of the semicells.

This form seems to be rare and has not previously been recorded from China.

COSMARIUM COSMOTIFORME, sp. nov. (Fig. 2, *13*)

C. submediocre, paullo longius quam latius, profundissime constrictum, sinus angusto-lineari; semicellulis a fronte visis transverse oblongis, angulis inferioribus superioribusque subrectangularibus, lateribus convexis subundulato-dentatis, dentis subcurvatis et obtusis, inferioribus constanter brevioribus quam superioribus, apicibus semicellularum latissime truncatis rectis et glabris, intra marginem lateralem dentibus obtusis 5 instructis, in area centrali cum granulis magnis saccatis 13 in seriebus verticalibus 5 et oblique 4, cum depressionibus triangularibus 6 circa granulum unumquemque, in centro depressionis cum scrobiculo; a vertice visis ellipticis, polis rotundatis dentibus obtusis 3 instructis, lateribus valde incrassatis et 5-undulatis; a latere visis subcircularibus, apicibus glabris, lateribus 3-undulatis et valde incrassatis; pyrenoidibus in utraque semicellula 2. Long. cell. sine dent. 38 μ, lat. sine dent. 32.5—33.5 μ, crass. 23.5; lat. isthm. 10—12 μ.

KS185: C, fairly common.

In general appearance this species seems to be closely allied to *C. cosmatum* W. et G. S. West, from which it is distinguished by the dissimilar shape of the semicells in

both front and vertical views, the different ornamentations, and the smaller cell dimensions. It should also be compared with *C. trachypleurum* Lund. and, especially, its variety *Nordstedtii* Gutw. The latter two are, however, chiefly characterized by that the semicells in front view are reniform in shape, only with seven large granules in the centre, with obtuse teeth on and within the lateral margins, and with punctations on the remaining part of the cell wall.

COSMARIUM CREPERUM W. et G. S. West var. SINENSE, var. nov. (Fig. 2, *2*)

Var. major; granulis majoribus et densioribus quam in forma typica. Long. cell. 42—45 μ, 38—41 μ, crass. 22—24 μ; lat. isthm. 15.5—17.0 μ.

KS185: C, scarce; *KS194,* rare.

This variety should be compared with *C. Quadrum* Lund. var. *minus* W. et G. S. West and *C. pseudobroomei* Wolle, but it differs from them chiefly in having an open sinus and more rounded sides of the samicells.

This species was described from Madagascar, and was again recorded only from East Africa and North America.

COSMARIUM CYCLICUM Lund. var. SINENSE, var. nov. (Fig. 2, *22*)

Var. semicellulis margine 20-crenatis, crenis intra marginem lateralem unumquemque 8 et intra marginem dorsalem nullis; angulis subrectis; a vertice visis ellipticis, utroque polo rotundatis et subtilissime crenulatis; a latere visis subcircularibus, apice rotundatis. Long. cell. 49.5 μ, lat. 49.5 μ, crass. 26 μ; lat. isthm. 19 μ.

KS112, rare.

In the front view, the cells of the Chinese plant are perfectly circular in outline, with a regularly undulate margin, and with a very narrow sinus which has a shortly dilated apex. These characteristics indicate that this alga is closely allied to *C. cyclicum.*

COSMARIUM DEPRESSUM (Naeg.) Lund., Nova Acta reg. soc. scient. Upsala, Ser. 3, 8: 38. 1871. (Fig. 1, *33*)

Eurastrum depressum Naeg., Gatt. einzell. Alg. 114, pl. 7: C, fig. 2. 1849.

Forma cellulis profundissime constrictis, paullo longioribus quam latis. Long. cell. 30 μ, lat. 25—27 μ, crass. 16.2 μ; lat. isthm. 5 μ.

KS75, rare.

The cells of a typical form of this species are always a little shorter than broad and have a sinus more than 10 μ in breadth. In 1902, W. and G. S. West described a form of this species from Ceylon (Trans. Linn. Soc. London, Ser. 2, Bot. 6: 164. 1902). The cells of their form also have a very narrow sinus, but they are slightly retuse in the middle of the apex of the semicells. The cell as a whole is shorter than broad.

COSMARIUM DISTICHUM Nordst. var. SUBOCTOGONUM, var. nov. (Fig. 2, *18*)

Var. cellulis aeque longis ac latis, ambitu suboctogonis; semicellulis angulari-subsemicircularibus, lateribus inferioribus leviter convexis et granulis magnis 3 instructis, superioribus subrectis et distincte convergentibus et granulis 2 ornatis, angulis basalibus obtuse rectangularibus, apice truncatis rectisque, infra et juxta marginem apicalem granulis minutissimis 4 instructis, supra medio semicellulae seriebus duabus vel rarissime tribus granulorum magnorum transverse dispositis ornatis, granulis 2 in serie superiore,

3 in serie inferiore, rarissime aliis 2 in serie infima; a vertice visis rhomboideo-ellipticis, angulis omnibus truncatis, seriebus granulorum inter apices continuis (in medio non interruptis); a latere visis obovato-circularibus, lateribus superioribus distincte incrassatis et granulis magnis 2 vel rarissime 3 instructis, apice subtruncatis, granulis minutissimis 2 ornatis, in medio seriebus verticalibus parallelis (non deorsum convergentibus) 2 granulorum ornatis. Long. cell. 32—33 μ. lat. 32 μ, crass. 22—23 μ; lat. isthm. 9 μ.

KS185, scarce.

In general appearance, this new variety bears some resemblance to *C. taxichondrum* Lund. var. *subundulatum* Boldt. f. *subdenticulatum* W. et G. S. West. As the Chinese plant possesses two series of granules in the margin of the semicell, it seems to be better to refer it to *C. distichum* as a new variety.

COSMARIUM GARROLENSE Roy et Biss. var. CRASSUM, var. nov. (Fig. 1, *38*)

Var. marjor. Long. cell. 41.5—48.0 μ, lat. 31.5—34.5 μ, crass. 21.5—24.5 μ; lat. isthm. 10.8 μ.

KS75, common; *KS76*, rather rare.

The Chinese plant agrees in all respects with *C. Garrolense* excepting that it has greater cell dimensions. This species has previously been recorded only from Europe.

COSMARIUM GLOBOSUM Bulnh., Hedwegia 2· 52, pl. 9, fig. 8. 1861. (Fig. 2, *17*)

Forma cellulis paullo angustioribus quam in forma speciei typica; semicellulis a vertice visis circularibus. Long. cell. 30 μ, lat. 18 μ;; lat. isthm. 12 μ.

KS201, rather common.

The Chinese plant should be compared with *C. moniliforme* (Turp.) Ralfs f. *punctata* Lagerh., in which the isthmus is comparatively narrower than that of *C. globosum*.

This species has not previously been recorded from China.

COSMARIUM GRANATUM Bréb. *in* Ralfs, Brit. Desm. 96, pl. 32, figs. 6: A and B. 1848.

Long. cell. 37—42 μ, lat. 25—27 μ, crass. 18 μ; lat. isthm. 9 μ.

KS180, rare; *KS183*, rather common; *KS194*, rare; *KS201*, common.

COSMARIUM GRANATUM Bréb. var. MIRIFICUM, var. nov. (Fig. 1, *35*)

Var. cellulis latioribus, sinu extremo subito aperto; semicellulis angulis basalibus subacute rectangularibus, lateribus in parte superiore convergentibus et leviter concavis, apicibus late truncatis; a vertice visis suboblongis; a latere visis elliptico-oblongis. Long. cell. 44—46 μ, lat. 32.5—35.0 μ, crass. 17 μ; lat. isthm. 9 μ.

KS153, rare.

In the front view, this alga seems to be closely allied to *C. Hammerii* Bréb., from which it is distinguished by its semicells being not tumid in the middle in both lateral and vertical views. It should also be compared with *C. trilobulatum* Reinsch., but it differs from the latter chiefly in having greater cell dimensions, semicells not so distinctly three-lobed, and the sinus of the cell with a suddenly dilated apex.

COSMARIUM GRANATUM Bréb. var. SUBHAMMERII, var. nov. (Fig. 1, *34*)

Var. semicellulis apicibus latioribus quam in forma speciei typica, lateribus in parte superiore leviter concavis; a latere visis late ellipticis. Long. cell. 35 μ, lat. 27 μ, crass. 15 μ; lat. isthm. 9 μ.

KS153, rather common.

In front view, this variety seems to be closely related to *C. Hammerii* Bréb. As its semicells in both lateral and vertical views are not tumid at the middle, it may be better referred to *C. granatum* as a new variety. It differs from the preceding new variety in having different shape of the semicells in both lateral and vertical views and apex of the sinus of the cell not suddenly dilated.

COSMARIUM HEXAPAPILLATUM, sp. nov. (Fig. 2, *19*)

C. parvum, paullo longius quam latum, profundissime constrictum, sinu angusto-lineari; semicellulis transverse subelliptico-hexagonis, angulis lateralibus rotundatis, inferioribus rectangularibus, superioribus latissime rotundatis, lateribus inferioribus divergentibus, superioribus convergentibus, apicibus truncatis rectisque; membrana juxta et intra angulum lateralem granulis 2 et intra illum superiorem granulo 1 instructis; a vertice visis subrhomboideo-ellipticis, polis rotundatis et bigranulatis, medio utrobique tumidis et triundulatis; a latere visis subobovato-circularibus, apice late truncatis; pyrenoidibus in utraque semicellula singulis. Long. cell. 33.5 μ. lat. 30 μ, crass. 19 μ; lat. isthm. 8 μ.

KS185: C, rare.

This species approaches *C. pseudoprotuberans* Kirchn. and especially its form *minus* Wille very closely, but it differs from them chiefly in having different shape of the semicells and the cell wall furnished with six distinct granules just within the margin of each semicell when the plant viewed from the front. It should also be compared with *C. sexangulare* Lund. and *C. repundum* Nordst., which have greater cell dimensions, the different shape of the semicells in front, lateral, and vertical views, and a smooth cell wall.

COSMARIUM IMPRESSULUM Elfv., Act. Soc. Fauna Flora Finn. 5: 13, pl. 1, fig. 9. 1881.

Long. cell. 27—29 μ, lat. 18—21 μ, crass. 12—13 μ; lat. isthm. 5.5—8.0 μ.

KS192, scarce.

COSMARIUM KWANGSIENSE, sp. nov. (Fig. 2, *14*)

C. parvum, tam longum quam latum, profundissime constrictum, sinu lineari extremo ampliato; semicellulis depresso-semicircularibus, angulis basalibus rotundatis, membrana granulis obtuse conicis numerosis irregulariter dispositis et in centro semicellularum papilla magna instructa; a vertice visis perfecte ellipticis, in medio utrobique papilla magna hemisphaerica ornatis; a latere visis depresso-circularibus, in medio utrobique papilla magna instructis; pyrenoidibus singulis. Long. cell. sine granul. 22.5 μ, cum granul. 24.5 μ, lat. sine granul. 22.5 μ, cum granul. 24.5 μ, crass. sine papill. centr. 14 μ, cum papill. centr. 16.5 μ; lat. isthm. 6.3 μ.

KS185: C, rare.

It seems to be that this species approaches *C. margaritiferum* Menegh. f. *Kirchneri* (Börges.) W. et G. S. West very closely, but it is distinguished from the latter by its

smaller cell dimensions, the different shape of its sinus and semicells, and the different ornamentation on the centre of its semicells.

COSMARIUM LUNDELLII Delp. var. CORRUPTUM (Turn.) W. et G. S. West, Trans. Linn. Soc. London, Ser. 2, Bot. 6: 162; Monogr. Brit. Desm. 2: 139, pl. 57, figs. 5—6. 1905. (Fig. 2, *20*)

Cosmarium corruptum Turn., K. Sv. Vet.-Akad. Handl. 25: 51, pl. 8, fig. 2. 1893.
Cosmarium subcirculare Turn., loc. cit., 52, pl. 8, fig. 3.

Forma paullo minor; angulis inferioribus semicellularum subtruncatis et distincte incrassatis; semicellulis a vertice visis sexangulari-ellipticis, polis truncatis; membrana minute et irregulariter scrobiculata, scrobiculis magnitudine similibus (non major apud marginem). Long. cell. 46—47 μ, lat. 40.0—42.5 μ, crass. 24.5—27.0 μ; lat. isthm. 21.6 μ.

KS157, fairly common.

As described by Turner, the cell wall of *C. corruptum* is "punctata vel minute granulosa" (loc. cit.). Owing to the fact that the punctation is quite different from the granulation in nature, the writer thinks that the punctate individuals can not be combined with the granulate ones in a single species. Judging from Turner's drawing of *C. corruptum,* especially figure 2, b and d, in plate 8, the ornamentation on the cell wall is undoubtedly the punctations similar to those appeared in *C. Lundellii.* It is, however, not the granulations.

W. and G. S. West combined *C. corruptum* Turn. *C. subcirculare* Turn. var. *rugosum* Turn., and *C. rotundatum* Turn. as a single variety of *C. Lundellii* under the name *C. Lundellii* var. *corruptum* (loc. cit.). Judging from Turner's drawing of *C. subcirculare* var. *rugosum* (loc. cit. pl. 8, fig. 7), there are the distinct rectangular warts regularly arranged into concentric and radiating rows on the cell wall. According to his diagnosis and drawing of *C. rotundatum* (loc. cit., p. 58, pl. 8, fig. 48) the cell wall is characterized by "marginem versus granulata, granulis in series regulare, concentricas ordinatis (magnitudo major apud marginem)". If the original diagnosis and drawings of *C. subcirculare* var. *rugosum* and *C. rotundatum* were correctly made by Turner, the ornamentation on their cell wall is, however, quite different from that on *C. corruptum* Turn. Thus the writer does not agree with Wests's consideration in combining these three different plants in a single variety.

Furthermore, *C. subcirculare* Turn. (loc. cit.) agrees nearly in all respects with *C. corruptum* Turn. It may be better considered as a synonym of *C. Lundellii* var. *corruptum.*

COSMARIUM LUNDELLII Delp. var. PSEUDOTUDDALENSE, var. nov. (Fig. 2, *21*)

Var. duplo-minor, marginibus semicellularum irregulariter undulatis. Long. cell. 36—38 μ, lat. 32.5—36.0 μ, crass. 20—21 μ; lat. isthm. 10—12 μ.

KS185: C, common; *KS201,* common.

In all views, the cell of this new variety agrees entirely in shape with *C. Lundellii,* but it is smaller in size and has irregularly undunate margins in the semicells. The cell wall is somewhat similar to that of *C. tuddalense* Strøm (f.) figured by Prof. W. R. Taylor (Papers Mich. Acad. Aci., Arts and Lett. 19: pl. 69, figs. 8 and 9. 1934), but the Strøm's species has greater cell dimensions and different shape of the semicells.

COSMARIUM MACULATUM Turn., K. Sv. Vet.-Akad. Handl. 25: 49, pl. 7, fig. 31; pl. 8, fig. 68 (forma); W. and G. S. West, Trans. Linn. Soc. London, Ser. 2, Bot. 6: 163. 1902.

Long. cell. 118 μ, lat. 70—73 μ, crass. 60 μ; lat. isthm. 53 μ.

KS75, fairly common; *KS112,* rare.

COSMARIUM MACULATUM Turn. var. MAJOR, var. nov. (Fig. 3, *1*)

Var. major; chromatophoris 12 in semicellula unaquaque. Long. cell. 178 μ, lat. 90 μ, crass. 75 μ; lat. isthm. 55 μ.

KS76, fairly common.

In the typical form of this species, there are only six chromatophores in each semicell and its cell dimensions are smaller than those of this new variety.

COSMARIUM MALIVERNIANUM (Racib.) Schmidle var. BADENSE Schmidle f. TROPICA Gutw., Bull. Acad. Acad. Carc. 1902: 597, pl. 39, fig. 48. 1902. (Fig. 3, *11* & *12*)

Long. cell. 73—79 μ, lat. 56.5—60.5 μ, crass. 38—44 μ; lat. isthm. 23.4—25.2 μ.

KS75, fairly common.

In the Chinese plant, the structure of the central area of the semicells is dissimilar to that shown in Gutwinski's original drawings of this form (loc. cit.). In the well developed individuals, each granule in such area is not only surrounded by six triangular depressions but also by six elliptical ones. These two kinds of depressions are arranged alternately to one another and radiate toward a hollow granule. The writer has examined quite a number of specimens of this alga, and found out that the elliptical depressions are originated from a gradual longitudinal split of the simple ridges between the triangular depressions (fig. 2, *12*). In some individuals, the process of splitting in different stages can be clearly traced out.

W. and G. S. West considered *C. Malinvernianum* var. *Badense* and, with no certainty, the species *C. Malinvernianum* as the synonymes of *C. magaritiferum* Menegh. (Monogr. Brit. Desm. 3: 199; 201. 1908). In 1921, Grönblad has given proof to the fact that *C. Malinvernianum* should be reestablished as an independent species (Acta Soc. Fauna Flora Fenn. 49: 32. 1921). Grönblad's opinion is now adopted by the writer.

This form has previously been recorded only from Java by Gutwinski in 1902. It is very interesting to discover it in China.

COSMARIUM MARGARITATUM (Lund.) Roy et Biss., Journ. Bot. 25: 194. 1886.

Cosmarium latum Bréb. var. *margaritatum* Lund., Nava Acta reg. Soc. Scient. Upsala, Ser. 3, 8: 26. 1871.

Long. cell. 74—81 μ, lat. 60—63 μ, crass. 42—46 μ; lat. isthm. 20—27 μ.

KS101, fairly common.

The specimens of this species found in this sample is quite typical. In the sample KS119: B, the writer found few more individuals which should also be referred to this species. In general shape, they agree fairly well with f. *subrotundata* W. et. G. S. West of this species, but they have the granules similar to those of its type species. This alga may be considered as a form of this species with the following data:

Forma semicellulis a fronte visis subreniformibus; ceterum ut in forma speciei typica. Long. cell. 70 μ, lat. 61 μ, crass. 36 μ; lat. isthm. 20 μ.

COSMARIUM MENEGHINII Bréb. *in* Ralfs, Brit. Desm. 96, pl. 15, fig. 6. 1848.
Long. cell. 18—20 μ, lat. 13.5—14.5 μ, crass. 9 μ; lat. isthm. 4.5 μ.
KS76, common.

COSMARIUM MONILIFORME (Turp.) Ralfs, Brit. Desm. 107, pl. 17, fig. 6. 1848.
Long. cell. 37—38 μ, lat. 22—23 μ; lat. isthm. 9 μ.
KS185: C, common.

COSMARIUM NORIMBERGENSE Reinsch., Spec. Gen. Alg. 117, pl. 22 A iv, figs. 1—11. 1867. (Fig. 1, 25)

Forma cellulis diametro 1¼-plo longioribus; semicellulis e vertice visis late ellipticis (1: 1.3), a latere visis subobovato-circularibus. Long. cell. 21 μ, lat. 17.5—18.0 μ, crass. 11.5—13.5 μ; lat. isthm. 5.4 μ.
KS75, rare; *KS157,* rare.

COSMARIUM OBSOLETUM (Hantzsch) Reinsch. var. DORSITRUNCATIFORME (Gutw.), nob.
Cosmarium dorsitruncatiforme Gutw., Bull. Acad. Sci. Crac. 1902: 592, pl. 38, fig. 35. 1902.
Long. cell. 40—42. μ, lat. 40—49 μ, crass. 24—27 μ; lat. isthm. 20.0—22.5 μ.
KS75, common; *KS157,* rare.

The writer does not think that *C. dorsitruncatiforme* Gutw. differs suffeciently from *C. obsoletum* (Hantzsch) Reinsch. to warrant its separation as a distinct species, therefore, he regards it as a variety of the latter. It is characterized chiefly by its truncate apex of the semicells.

COSMARIUM OBSOLETUM (Hantzsch) Reinsch. var. SITVENSE Gutw., Bull. Acad. Sci. Crac. 1902: 594, pl. 38, fig. 39. 1902.
Long. cell. 69—73 μ, lat. 76.5—77.5 μ, crass. 38—40 μ; lat. isthm. 37—38.7 μ.
KS119, rather common; *KS137,* rather rare.

This variety is known to be a large tropical form of this species inhabiting in the Indo-Malaya region. The cell dimensions of the Chinese plant are still greater than those of the typical form of the var. *Sitvense.*

COSMARIUM OBTUSATUM Schmidle, Engl. Bot. Jahrb. 26: 38. 1898.
Cosmarium undulatum Corda var. *obtusatum* Schmidle, Bericht. Deutsch. Bot. Gesellsch. 11: 550, pl. 28, fig. 11. 1893.
Long. cell. 63 μ, lat. 45.0—45.5 μ, crass. 29 μ; lat. isthm. 16.2 μ.
KS76, common; *KS179,* rare; *KS184,* rare; *KS201,* common.

COSMARIUM PACHYDERMUM Lund., Nova Acta reg. Soc. Scient. Upsale, Ser. 3, 8: 39, pl. 2, fig. 15. 1871.
Long. cell. 79 μ, lat. 63 μ, crass. 41 μ; lat. isthm. 28.8 μ; crass. membr. 2.5 μ.
KS76, fairly rare.

COSMARIUM PHASEOLUS Bréb. var. ELEVATUM Nordst., Act. Univ. Lund. 9: 17, pl. 1, fig. 5. 1873.
Long. cell. 25 μ, lat. 28 μ, crass. 16 μ; lat. isthm. 6.5 μ.

KS201, scarce.

Cosmarium polygonum (Naeg.) Arch. *in* Pritch., Hist. Infus. 732. 1861; W. and G. S. West, Monogr. Brit. Desm. 3: 76, pl. 71, figs. 32—34. 1908. (Fig. 1, *36*)

Long. cell. 16.2 μ, lat. 14.4 μ crass. 10.0—12.5 μ; lat. isthm. 4.5 μ.

KS192, rare.

This species has not previously been recorded from China.

Cosmarium portianum Arch., Quart. Journ. Micr. Sci. 8: 235, pl. 11. 1860; W. and G. S. West, Monogr. Brit. Desm. 3: 165, pl. 130, figs. 4—7. 1908.

Forma typica: Long. cell. 29—30 μ, lat. 22—23 μ, crass. 16.2 μ; lat. isthm. 8.0—8.5 μ.

KS157, rather rare; KS185: C, rare; KS183, rare.

Forma tropica: Long. cell. 26—27 μ, lat. 18 μ, crass. 15 μ; lat. isthm. 9 μ.

KS192, rare.

As stated by W. and G. S. West, "the tropical forms of this species are considerably smaller than those occurring in temperate regions. (Length 20—25 μ; breadth 14.5—19 μ; breadth of isthmus 5—8.5 μ; thickness 10—12.5 μ)" (loc. cit. 167). In the writer's sample No. *KS192*, the individuals of this species have the cell dimensions nearest to those of the tropical forms. In the sample No. *KS157*, their measurements approach to those of the temperate-region.

Cosmarium pseudadoxum, sp. nov. (Fig. 1, *30*)

C. parvum, circiter tam longum quam latum, profundissime constrictum, sinu breviter angusto-lineari extremo valde ampliato; semicellulis depresse truncato-pyramidatis et subtrilobatis, angulis inferioribus late rotundatis, superioribus subrectangulari-rotundatis, lateribus in parte superiore distincte retusis, apice late truncatis rectisque; a vertice visis ellipticis, polis rotundatis, papilla subhemisphaerica ad medium utrobique; a latere visis subcircularibus, cum papilla ad medium utrobique; pyrenoidibus singulis. Long. cell. 22.5—23.5 μ, lat. 20.5—21.5 μ; crass. sine papill. 11.5—12.5 μ, cum papill. 13.5—14.5 μ; lat. apic. semicell. 11—12 μ; lat. isthm. 6 μ.

KS76, fairly rare.

This species approaches both *C. adoxum* W. et G. S. West and *C. retusiforme* (Wille) Gutw. It differs from the first in having cells greater in size, different shape of its sinus, and sides of its semicells distinctly concaved in their upper portion, and from the second chiefly in having a distinct papilla on each side of the semicells.

Cosmarium pseudobroomei Wolle, Bull. Torr. Bot. Club 1884: 16, pl. 44, figs. 36—37. 1884.

Long. cell. 37—38 μ, lat. 36—41 μ, crass. 20—21 μ; lat. isthm. 14.4 μ.

KS185, rare.

Cosmarium pseudoconnatum Nordst., Vidensk. Medd. Naturh. Foren. Kjöbenhavn 1869: 214, pl. 3, fig. 17. 1870.

Long. cell. 82—86 μ, lat. 54—58 μ; lat. isthm. 51—54 μ.

KS75, common, *KS119*, rather common; *KS185*, scarce.

Borge has described a large form of this species (Arkiv Bot. 1: 94. 1903). Its dimensions (long. cell. 80—86 μ; lat. 62—67 μ; lat. isthm. 59—63 μ) are almost entirely similar to those of the Chinese plant.

COSMARIUM PSEUDOCONNATUM Nordst. var. SUBCONSTRICTUM, var. nov. (Fig. 3, *2*)

Var. cellulis majoribus, levissime constrictis; semicellulis semiellipticis, in basi non convergentibus; membrana minutissime punctata. Long. cell. 80—85 μ, lat. 50—57 μ; lat. isthm. 47—55 μ.

KS112, fairly rare; *KS119,* rare; *KS185: C,* fairly common.

The semicells of the typical form of *C. pseudoconnatum* are also semielliptic, but with a slightly narrowed base. In this new variety, the base of the semicells is, however, not in such a manner.

COSMARIUM PSEUDONITIDULUM Nordst. var. VALIDUM W. et G. S. West, Monogr. Brit. Desm. 2: 196, pl. 63, figs. 27—30. 1905.

Long. cell. 54—70 μ, lat. 45—57 μ, crass. 27.5—32.5 μ; lat. isthm. 19—20 μ.

KS137, common; *KS153,* scarce.

In Asia, this variety has previously been recorded only from India, Ceylon, and Singapore.

COSMARIUM QUADRATUM Ralfs, Ann. Mag. Nat. Hist. 1844: 395, pl. 2, fig. 9. 1844. (Fig. 3, *3*)

Forma apice semicellularum alte convexo, in medio cum nodulo incrassato; cellulae a latere visae cylindricae, polis rotundatae; membrana minutissime punctata. Long. cell. 65—66 μ, lat. 33—34 μ, crass. 25 μ; lat. isthm. 16.2 μ.

KS153, rare.

In form, the Chinese plant is nearest to *C. quadratum* Ralfs forma Borge (Mat.-Naturv. Klasse 1911: 13, fig. 10. 1911), but it has the narrower but somewhat longer cells, narrower isthmus, finely punctate cell-wall, and middle of the apex of the semicells with a distinct nodule. Borge did not give a description or a drawing of the cells in the lateral view for his form. It is, therefore, impossible to compare it with the Chinese alga. However, the lateral view of the Chinese alga is not identical to the typical form of this species.

COSMARIUM QUADRUM Lund., Nova Acta reg. Soc. Scient. Upsala, Ser. 3, 8: 25, pl. 2, fig. 11. 1871.

Long. cell. 61.5—68.5 μ, lat. 57.5—63.0 μ, crass. 28.5—31.5 μ; lat. isthm. 21.6—23.4 μ.

KS76, KS119, KS137, KS180, KS184, KS192, and *KS201,* all fairly rare.

This species distributed in both Yangso and Suijen districts is fairly common in occurance but not very abundant in number.

COSMARIUM RECTANGULARE Grun. var. INCRASSATUM, var. nov. (Fig. 1, *23*)

Var. semicellulis a fronte visis angulis basalibus rotundatis, apice incrassatis; a vertice visis ad medium utrobique plus minusve incrassatis; a latere visis octangulari-circularibus, lateribus et angulis superioribus et apice distincte incrassatis. Long. cell. 38 μ, lat. 25 μ, crass. 17.5 μ; lat. isthm. 8 μ.

KS192, scarce.

COSMARIUM REGNLSI Reinsch. var. MONTANUM Schmidle, Hedwigia 34: 74, pl. 1, fig. 9. 1895. (Fig. 1, *26*)

Forma apicibus semicellularum leviter concavis. Long. cell. 11.7—12.6 μ, lat. 10.0—12.6, crass. 5.4 μ; lat. isthm. 4.5—5.4 μ.

KS185: C, rare.

It seems to be that the Chinese plant is an intermediate form of the var. *montanum* and another variety of this species, *productum* W. et G. S. West. It is, however, more closely allied to the first.

COSMARIUM RENIFORMF (Ralfs) Arch. var. APLRTUM W. et G. S. West, Monogr. Brit. Desm. 3: 157, pl. 79, fig. 5. 1908. (Fig. 2, *1*)

Long. cell. 45—48 μ, lat. 42—43 μ, crass. 23.5—25.5 μ; lat. isthm. 16.2 μ.

KS76, rare.

This variety has previously been recorded only from Ireland by W. and G. S. West. It seems to have some resemblance to *C. creperum* W. et G. S. West, from which it differs in having different shape of the semicells in the front view and different shape of the sinus.

COSMARIUM RLPANDUM Nordst. f. MINOR W. et G. S. West, Journ. Linn. Soc. Bot. 33: 303. 1898; Monogr. Brit. Desm. 3: 54, pl. 69, figs. 31 and 32, 1908. (Fig. 1, *32*)

Long. cell. 19 μ, lat. 16.3 μ, crass. 10 μ; lat. isthm. 5.4 μ.

KS153, very rare.

This form has not previously been recorded from China.

COSMARIUM SPYRIDION W. et G. S. West var. SUBANGULATUM, var. nov. (Fig. 1, *28* & *29*)

Var. semicellulis a fronte visis angulis lateralibus angulato-rotundatis, intra marginem granulis minutis 5 ornatis, apicibus latioribus quam in forma typica; papilla centrali magna, apice granulis elongato-ovatis radiatim ordinatis 6 ornata; a latere visis apice truncatis. Long. cell. 12 μ, lat. 12.5 μ, crass. 9 μ; lat. isthm. 5 μ.

KS185: C, rare.

This species has previously been recorded only from Madagascar and Ceylon.

COSMARIUM SUBAURICULATUM W. et G. S. West var. KWANGSIENSE, var. nov. (Fig. 2, *16*)

Var. paullo major; isthmo latiore quam in forma typica; sinu aperto acutangulo; semicellulis semicircularibus, apice subtruncatis, angulis basalibus subrectangularibus et unidentatis. Long. cell. 51—54 μ, lat. sine spin. 46.8—48.6 μ, cum spin. 49.5—52.2 μ, crass. 33 μ; lat. isthm. 30.6 μ.

This species was described from Madagascar, and was again discovered from Siam, Nyasa, Victoria Nyanza, and Ningpo, Chekiang, China.

KS112, rare; *KS119,* fairly common; *KS157,* rare; *KS185:* C, scarce.

COSMARIUM SUBPROTUMIDUM Nordst., Öfvers. af K. Vet.-Akad. Förh. 1876: 38, pl. 12, fig. 14. 1876. (Fig. 2, *9* & *10*)

Long. cell. 22.5—26.0 μ, lat. 19.0—22.5 μ, crass. 13.5—14.5 μ; lat. isthm. 5.5—6.3 μ.

KS76, rather common; *KS157,* scarce; *KS192,* rare; *KS201,* rare.

This species has previously been recorded only from Europe and central Africa. The Chinese plant agrees fairly well with it in all respects excepting that the granulate central tumour is of different structure in some individuals (fig. 2, *10*)

COSMARIUM SUBSPECIOSUM Nordst. var. SIMPLICIUS, var. nov. (Fig. 2, *4*)

Var. semicellulis crenis omnibus simplicibus (non bigranulatis); tumore basali costis verticalibus granulatis 5, sectione transversa rotundatis, ornato; pyrenoidibus binis. Long. cell. 51.5 μ, lat. 40.5 μ, crass. 28.8 μ; lat. isthm. 14.4 μ; lat. apic. cemicell. 17 μ.

KS75, fairly common; *KS112,* scarce; *KS180,* scarece.

In the front view, this variety bears some resemblance to *C. formasulum* Hoff. *C. pulcherrimum* Nordst., *C. speciosum* Lund., and *C. binum* Nordst., but it is clearly distinguished from them by the shape of the semicells in both lateral and vertical views. It appears to the writer, that it is more closely allied to *C. subspeciosum* than any other species.

COSMARIUM SUBTUMIDUM Nordst. var. KWANGSIENSE, var. nov. (Fig. 1, *24*)

Var. minor, cellulis 1.5-plo longius quam latum; semicellulis a fronte visis truncato-semicircularibus vel subpyramidato-semicircularibus; a latere visis subrectangulari-circularibus; a vertice visis ellipticis, in medio utrobique leviter tumidis; membrana laevi. Long. cell. 27—28 μ, lat. 19 μ, crass. 13.5 μ; lat. isthm. 6.3 μ.

KS201, rare.

As the semicells of the Chinese plant possess the more convex sides and less angular apex in the front view, it seems to be that it is more closely allied to *C. subtumidum* rather than to *C. nitidulum* De Not. and *C. pseudonitidulum* Nordst.

COSMARIUM SUCCISUM West, Journ. Linn. Soc. Bot. 29: 146, pl. 20, figs. 22 and 23. 1892. (Fig. 1, *27*)

Forma sinu cellularum angusto-lineari extremo ampliato; semicellulis a vertice visis ellipticis, in medio utrobique non tumidis; membrana hyalina. Long. cell. 11.7—13.5 μ, lat. 11.7—13.5 μ, crass. 9 μ; lat. isthm. 4.5 μ.

KS201, rare.

COSMARIUM TURPINII Bréb. var. EXIMIUM W. et G. S. West, Monogr. Brit. Desm. 3: 192, pl. 83, fig. 3. 1908. (Fig. 2, *5*)

Forma paullo minor, apice semicellularum truncato recto et non distincte producto. Long. cell. 50 μ, lat. 40.5 μ, crass. 24 μ; lat. isthm. 11.5 μ.

KS201, scarce.

This variety has previously been recorded only from its type locality, near Westport, Mays, Ireland.

COSMARIUM UMBILICATUM Luetkem. var. GLABRUM, var. nov. (Fig. 1, *37*)

Var. semicellulis lateribus inferioribus distincte divergentibus et latioribus quam in forma typica, apice leviter retusis, tumore centrali non scrobiculatis; membrana glabra. Long. cell. 19.8 μ, lat. 16.2 μ, crass. 11.7 μ; lat. isthm. 4.5 μ.

KS157, rare.

In the typical form of this species, both sides of the semicells are almost equally triundulate in the front view, and their apex is comparatively widely truncate and straight. In the Chinese plant, the notch between the basal and the middle undulations is generally wider than that in the middle and upper ones and distinctly upwardly diverging. The apex is comparatively narrow and retuse. In these features, the semicells are, however, practically with the retuse sides and a quadri-undulate apex.

This species seems to be rare; it has previously been recorded only from Austria and England.

COSMARIUM VEXATUM West var. SINENSE, var. nov. (Fig. 2, *6*)

Var. lateribus semicellularum convexioribus quam in forma typica; membrana intra marginem lateralem superiorem bigranulata, supra isthmum granulis distinctis irregulariter ordinatis instructa; semicellulis a vertice visis ellipticis, in medio utrobique late tumidis; certrum ut in forma speciei typica. Long. cell. 42—45 μ, lat. 38.0—40.5 μ, crass 21.6—22.5 μ; lat. isthm. 10—11 μ.

KS76, fairly common.

In general appearance, the Chinese plant is closely allied to a form of this species figured by W. and G. S. West in their Monograph (Monogr. Brit. Desm. 3: pl. 92, fig. 5. 1908). It differs from the Wests' form in having distinct granules (not punctations) above the isthmus, paired granules within the upper part of both sides of the semicells, and different shape of the semicells in the vertical view.

This species has previously been recorded only from England and Germany.

ARTHRODESMUS Ehr.

ARTHRODESMUS CURVATUS Turn. var. XANTHIDIOIDES, var. nov. (Fig. 3, *4*)

Var. sinu introrsum breviter angusto-lineari; aculeis convergentibus incurvatis, raro leviter recurvatis, longioribus quam in forma speciei typica; membrana semicellularum in area centrali incrassata minute sed distincte scrobiculata et fuscescenti, ut in speciebus generis *Xanthidii;* semicellulis a vertice visis subanguste ellipticis, polis acutis. Long. cell. 37—38 μ, lat. sine acul. 39.5—42.5 μ, cum acul. 76.5—85.0 μ, crass. 17.5—20.7 μ; lat. isthm 10.8 μ.

KS185: C, rare.

As described by W. and G. S. West, the central area of the semicells of *Arthrodesmus* is quite plane and undifferentiated (Monogr. Brit. Desm. 4: 88. 1911). In 1920, Grönblad found an *Arthrodesmus, A. convergens* Ehr. var. *xanthidioides* Grönb., which is characterized by the "membrana semicellularum (a frante vis.) in area centrali incrassata fuscescentique, ut in speciebus generis *Xanthidii*" (Acta Soc. Fauna Flora Fenn. 47: 53. 1902). Thus he suggested that a part of Wests' diagnosis of the genus *Arthrodesmus* given in their Monograph should be emended as "centre of the semicell quite plane and undifferentiated or sometimes with a thickened (smooth or scrobiculated) more or less prominent central area; vertical view elliptic, with no medium protuberances, but sometimes with a medium thickening". These additional characteristics appeared in the species of *Arthrodesmus* are, however, extremely rare. Apart from *A. convergens* var. *xanthidioides,* the present new variety is a second example possessing such a well

differentiated central area of its semicells.

The genera *Xanthidium* and *Arthrodesmus* are, however, very closely related to each other. *A. convergens* var. *xanthidioides* and *A. curvatus* var. *xanthidioides* may be considered as the transational forms.

In general appearance, the new variety is nearest to *A. curvatus* var. *imatrensis* Groenb., which has a smooth cell wall.

Xanthidium Ehr.

Xanthidium acanthophorum Nordst., Acta. Univ. Lund. 16: 11, pl. 1, fig. 20. 1880. (Fig. 3, *5* & *6*)

Xanthidium acanthophorum Nordst. var. *bengalicum* Lagerh., Bih. K. Sv. Vet.-Akad. Handl. 13: 9, pl. 1, fig. 7. 1888.

Forma paullo major; aculeis ad marginem lateralem semicellularum brevioribus quam in forma typica. Long. cell. cum acul. 62—70 μ, sine acul. 50—54 μ, lat. cum acul. 62—63 μ, since acul. 44—47 μ, crass. 30—32 μ; lat. isthm. 15—16 μ; long. acul. 9—11 μ.

KS185: C, rare.

This species is an oriental *Xanthidium* described from Java and recorded again from India, Ceylon, and Burma, as well as in Sweden. It has not previously been recorded from China.

Xanthidium antilopaeum (Bréb.) Kuetz. var. basiornatum Eichl. et Rac., Rozpr. Wydz. mat.-przyr. Akad. Umiej. Krakow. 28: 125, pl. 3, fig. 31. 1893; Grönb., Acta Soc. Fauna Flora Fenn. 49: 46, pl. 4, figs. 17 and 18. 1921. (Fig. 3, *13*)

Forma aculeis validioribus asymmetrice dispositis; semicellulis a vertice visis rhomboidiformibus. Long. cell. sine acul. 48—50 μ, cum acul. 82—85 μ, lat. sine acul. 50—60 μ, cum acul. 80—89 μ, crass. 32—33 μ; lat. isthm. 22—23 μ; long. acul. 17—23 μ.

KS185: C, scarce.

In the Chinese plant, the scrobiculations across the base of each semicell vary from five to nine in number.

Xanthidium Freemanii W. et G. S. West, Trans. Linn. Soc. London, Ser. 2, Bot. 6: 158, pl. 20, fig. 28. 1902. (Fig. 3, *10*)

The writer presumes that he has seen the same plant that the Wests have observed, but the Wests' description and drawings of this species are unfortunately incomplete, he wishes to suggest an emended diagnosis with drawings in three views.

X. submagnum, paullo longius quam latum (sine spinis), subprofunde constrictum, sinu lineari extremo ampliato, semicellulis depresso-semicircularibus, apice truncatis rectis aut levissime retusis, angulis basalibus rotundatis, margine laterali unoquoque serie spinarum subacutarum subcurvatarum 8—10 praeditis, et seriebus duabus vel singulis spinarum similium 7—10 intra marginem, apice non spinulatis; membrana irregulariter et minute scrobiculata, in centro semicellularum valde incrassata lutea et scrobiculis paullo majoribus irregulariter ordinatis ornatis; a vertice visis ellipticis, ad polos rotundatos spinis 4—6 instructis, intra polos seriebus parallelis 6—7 spinarum transverse dispositis, ad medium utrobique valde incrassatis sed non inflatis; a latere visis subobovato-

circularibus, seriebus subparallelis 8—10 spinarum transverse dispositis, in medio utrinque distincte incrassatis; pyrenoidibus in utraque semicellula 2. Long. cell. sine spin. 100 μ, cum spin. 110 μ, lat. sine spin. 78—81 μ, cum spin. 90—95 μ, crass. 54 μ; lat. isthm. 37—38 μ; long. spin. 8—10 μ.

KS119, rare.

This very conspicuous species has previously been recorded only once from Ceylon by Wests.

XANTHIDIUM HASTIFERUM Turn. var. JAVANICUM Turn., K. Sv. Vet.-Akad. Handl. 25: 100. 1893.

Xanthidium antilopaeum (Bréb.) Kuetz. f. *javanica* Nordst., Acta Univ. Lund. 16: 12, pl. 1, fig. 23. 1880.

Long. cell. sine acul. 43—48 μ, cum acul. 75—88 μ, lat. sine acul. 38—41 μ, cum acul. 70—88 μ, crass. 23—25 μ; lat. isthm. 10.0—12.5 μ; long. acul. usque ad 23 μ.

KS185: C, scarce.

XANTHIDIUM RACIBORSKII Gutw. var. GLABRUM, var. nov. (Fig. 3, 7)

Var. angulis omnibus semicelluarum distincte conice protractis et regulariter quadridentatis; semicellulis a latere visis subrhomboideo-circularibus, apice conice protractis et quadridentatis; membrana glabra (non granulata); certrum ut in forma speciei typica. Long. cell. sine spin. 48.5—49.5 μ, cum spin. 54—55 μ, lat. sine spin. 45.0—46.8 μ, cum spin. 49.5—52.5 μ, crass. 29.5—30.0 μ; lat. isthm. 20.7 μ; lat. apic. semicell. 25.2—26.1 μ; long. spin. 2.7—4.5 μ.

KS75, scarce.

This variety is characterized by its smooth cell wall, all angules of its semicells constantly 4-spined, and its semicells being rhomboid in the vertical view and rhombic-circular in the lateral view. These characteristics not only distinguish the new variety from its type species but also from *X. Raciborskii* f. *protracta* Gutw.

It also bears some resemblance to *X. Smithii* Arch. and its variety *variabile* Nordst., but it differs from them collectively in having different shape of the sinus, four spines on each angule of the semicells, and greater cell dimemsions.

This species has previously been recorded only from Java.

XANTHIDIUM SUBTRILOBUM W. et G. S. West var. KRIEGERII, var. nov. (Fig. 3, *8*)

Xanthidium subtrilobum W. et G. S. West forma Krieger, Arch. Hydrobiol., Suppl.-Bd., 11: 1932; Rich, Trans. Roy. Soc. S. Afr. 23: 141, fig. 15, A. 1935.

Long. cell. sine acul. 57.5—58.5 μ, cum acul. 83—89 μ, lat. sine acul. 52—56 μ, cum acul. 73—89 μ; crass. ?, lat. isthm. 13.5—15.0 μ.

KS185: C, rare.

The shape and the ornamentations of the Chinese plant closely resemble those of the form of this species as described by Krieger from Sumatra and recorded by Rich from Southern Rhodesia, South Africa (loc. cit.). As the widely open sinus and the stronger spines appeared in the specimens collected from different localities seem to be constant, Krieger's form may be better considered as a distinct variety.

XANTHIDIUM SUPERBUM Elfv., Acta Soc. Fauna Flora Fenn. 5: 10, pl. 1, fig. 6. 1881. (Fig. 3, 9)

Long. cell. sine acul. 98 μ, cum acul. 125 μ, lat. sine acul. 58—63 μ, cum acul. 90—98 μ, crass. 44—45 μ; lat. isthm. 18—20 μ.

KS185 and *KS185: C,* scarce.

This beautiful alga seems to be very rare. Since Elfving described it from Finland in 1881 and Borge found a form of the species from Australia in 1896, there is no additional record on its distribution.

The Chinese plant agrees in all respects with Elfving's description and drawing, except each semicell is sometimes furnished with seven pairs of long spines and occasionally with additional short spine on one or two apical warts. The cell wall is finely punctate.

STAURASTRUM Meyen

STAURASTRUM APICULATUM Bréb., Mem. d. l. soc. imp. des Sciences nat. de Cherbourg. 4: 142, pl. 1, fig. 23. 1856.

Long. cell. 21.6 μ, lat. 21.6 μ; lat. isthm. 6.3 μ.

KS75, scarce.

STAURASTRUM ARISTIFERUM Ralfs var. PROJECTUM, var. nov. (Fig. 4, 8)

Var. duplo-major, sinu cellularum aperto subrectangulari; semicellularis a fronte visis late subcuneatis, a basi late rotundata gradatim dilatatis, lateribus in media parte retusis, apice leviter convexo, angulis divergentibus et plus minusve longe productis, spino longo valido erecto instructis; a vertice visis tri-radiatis, lateribus retusis sed in media parte leviter convexis. Long. cell. sine spin. 45—63 μ, cum spin. 62—88 μ, lat. sine spin. 47—50 μ, cum spin. 55—58 μ; lat. isthm. 15.5—16.2 μ; long. spin. 12.5—13.5 μ.

KS185: C, scarce.

This alga is not only closely allied to *S. aristiferum* Ralfs but also approaches *S. leptodermum* Lund. and its varieties *Ikapoae* (Schmidle) W. et G. S. West and *subcorniculatum* Rich very closely. As it possesses the proportionally narrower isthmus, the long spines, and the distinctly retuse sides of the semicells in the lateral view, the writer thinks that it may be better referred to *S. aristiferum* as a new variety.

STAURASTRUM BICORONATUM Johnson var. KWANGSIENSE, var. nov. (Fig. 5, 9)

Var. major, semicellulis a fronte visis campanulatis, apice alte productis truncatisque, processibus leviter incurvatis, apice processuum quadridentatis, margine spuperiore processuum verrucis magnis bispinatis sed apicem processuum versus minoribus papilliformibusque instructis, inferiore verrucoso-undulatis; a vertice visis marginibus processuum undulatis. Long. cell. 25.2 μ, lat. 30.5—32.5 μ; lat. isthm. 6.3 μ.

KS192, scarce.

This variety differs from the other varieties of this species, viz., var. *sinense* Lütkem., var. *javanica* (Nordst.) Lütkem., and var. *alpinum* (Schmidle) Lütkem., in having different shape of the semicells, dissimilar dimensions of the cells, and different ornamentations on the cell wall.

STAURASTRUM BIFIDUM (Ehr.) Bréb. var. TORTUM Turn., K. Sv. Vet.-Akad. Handl. 25: 108, pl. 15, fig. 8. 1892.

Long. cell. 34—40 μ, lat. sine spin. 34—49 μ, cum spin. 41—67 μ; lat. isthm. 15—16 μ.

KS75, scarce.

The individuals of this variety found in this sample are more or less various in size and shape of the cells. In the lateral view, the apex of the semicells is mostly slightly concave; but, in some other individuals, it may be either slightly convex or somewhat distinctly umbolate. The spines also show a considerable degree of variation in their length and position in different individuals.

The typical form of this variety has not perviously been recorded from China.

STAURASTRUM CONNATUM (Lund.) Roy et Biss. var. RECTANGULUM Roy et Biss., Journ. Bot. 25: 237, pl. 269, fig. 12. 1871. (Fig. 4, *17*)

Forma semicellulis angulis superioribus subacutis et plus minusve productis, lateribus in media parte rectis; a vertice visis lateribus valde retusis. Long. cell. sine spin. 22.5, cum spin. 36 μ, lat. 25.2 μ; lat. isthm. 6.3 μ; long. spin. 7.2—8.1 μ.

KS185: C, rare.

This variety has not previously been recorded from China.

STAURASTRUM CONTECTUM Turn. var. INEVOLUTUM Turn., K. Sv. Vet.-Akad. Handl. 25: 111, pl. 16, fig. 2; pl. 22, fig. 11. 1892. (Fig. 4, *11*)

Forma paullo major. Long. cell. sine spin. 27 μ, cum spin. 32 μ, lat. sine spin. 28—29 μ, cum spin. 34—36 μ; lat. isthm. 12 μ; long. proc. 3—4 μ; long. spin. 4—6 μ.

KS137, rare.

STAURASTRUM CONTECTUM Turn. var. QUADRIDENTATUM, var. nov. (Fig. 4, *10*)

Var. processibus brevioribus, apice quadrangularibus et regulariter quadridentatis; spinis tenuioribus; apice semicellularum leviter concavo. Long. cell. 27 μ, lat. sine spin. 27 μ, cum spin. 30.6 μ; lat. isthm. 11.7 μ.

KS192, common.

One of Turner's figures of *S. contectum* var. *inevolutum* (K. Sv. Vet.-Akad. Handl. 25: pl. 16, fig. 2. 1892) shows that the processes in the end view looks like 4-dentate, but he did not state this character in his diagnosis of this variety (loc. cit., 111). In *S. contactum*, the end of the processes is deeply bifurcated and nearly circular in outline in the end view. In the new variety, the end of the processes is, however, constantly 4-dentate and rectangular. Furthermore, the processes of the new variety are shorter than those of its type species *S. contectum* and another variety *inevolutum*.

STAURASTRUM CONTECTUM Turn. var. KWANGSIENSE, var. nov. (Fig. 4, *9*)

Var. semicellulis a fronte visis marginibus dorsi ventrumque rectis, angulis et processibus brevissime productis, angulis superioribus uni- vel rarissime bi-aculeatis, aculis tenuioribus et paullo brevioribus; a vertice visis 3- vel 4-gonis, lateribus leviter concavis. Long. cell. 22.5—25.5 μ, lat. sine spin. 25—30 μ, cum spin. 31.5—35.0 μ; lat. isthm. 9.0—11.5 μ.

KS75, KS137, and *KS157,* rare.

STAURASTRUM CRENULATUM (Naeg.) Delp., Sp. Desm. subalp. 164, pl. 12, figs. 1—11. 1877.

Long. cell. 23.5—27.0 μ, lat. sine spin. 27.0—30.5 μ, cum spin. 30.5—35.0 μ; lat. isthm. 6.3—7.2 μ.

KS76, rare.

This species has not previously been recorded in China.

STAURASTRUM DEJECTUM Bréb. *in* Menegh., Synops. Desm. 227. 1840.

Forma paullo major. Long. cell. 29.5—30.0 μ, lat. sine spin. 34.5—38.5 μ, cum spin. 50—57 μ; lat. isthm. 7.5 μ; long. spin. 8—11 μ.

KS185: C, scarce.

STAURASTRUM DICKIEI Ralfs var. CIRCULARE Turn., K. Sv. Vet.-Akad. Handl. 25: 105, pl. 16, fig. 5. 1893. (Fig. 4, *5*)

Forma sinu cellularum angusto-lineari extremo ampliato; semicellulis subpyramiato-circularibus; membrana minute punctata. Long. cell. 36 μ, lat. sine spin. 33.3 μ, cum spin. 36 μ; lat. isthm. 9.9 μ.

KS192, rare.

STAURASTRUM ENSIFERUM Turn., K. Sv. Vet.-Akad. Handl. 25: 109, pl. 14, fig. 22. 1893. (Fig. 4, *15*)

Forma semicellulis a fronte visis angulis non productis, margine apicali fere rectis. Long. cell. sine acul. 40.5 μ, cum acul. 63 μ, lat. sine acul. 38.7 μ, cum acul. 57.6 μ; lat. isthm. 12 μ; long. acul. 6—11 μ.

KS185: C, scarce.

STAURASTRUM EXCAVATUM W. et G. S. West forma W. et G. S. West, Journ. Linn. Soc. Bot. 39: 71, pl. 6, figs. 19; 20. 1909. (Fig. 5, *12*)

Long. cell. 14.4 μ, lat. sine spin. 40 μ, cum spin. 45 μ, crass. 8 μ; lat. isthm. 5.4 μ.

KS185: C, rare.

This species seems to be rare in occurance. It was described by Wests from Madagascar in 1895 (Trans. Linn. Soc., Ser. 2, Bot. 5: 78, pl. 8, fig. 42. 1895), and was again recorded by Playfair from New South Wales in 1907 (Proc. Linn. Soc. New South Wales 32: 187, pl. 5, fig. 3. 1907). In 1909, Wests found a form of this species in Victoria (loc. cit.). Apart from these localities, no additional records has since been made from any other part of the world. It is of much interest that the Victoria from is now found in China.

The Chinese plant agrees in all respects with the Victoria form, except that its processes end in four comparatively strong teeth instead of three.

STARUSTRUM FORFICULATUM Lund. var. ELLIPTICUM, var. nov. (Fig. 4, *18*)

Var. minor; sinu acutangulo aperto; semicellulis a fronte visis late transverse ellipticis, dorso in media parte anguste truncato, utrobique verrucis bidentatis 2 et spina brevi instructo, ventre leviter 2- vel 3-crenulato, polis inaequaliter biaculeatis, aculeo superiore brevi, inferiori elongato et plerumque introrsum incurvato; a vertice visis trigonis, lateribus leviter concavis 4-undulatis et in media parte spinis brevibus 2 instructis, cum verrucis bidentatis 4 intra marginem, angulis aculeactis, intra angulum spinis brevis 2 ornatis. Long. cell. sine verr. 28 μ, cum verr. 32.5 μ, lat. sine acul. 29.5—31.5 μ, cum acul. 35.0—42.5 μ; lat. isthm. 11—12 μ.

KS185: C, rare.

This variety differs from its type species chiefly in having different shape of the semicells and different ornamentations on the cell wall.

STAURASTRUM FORFICULATUM Lund. var. SIMPLICIUS, var. nov. (Fig. 5, *5*)

Var. minor, sinu aperto acutangulo; semicellulis a fronte visis transverse ellipticis dorso in media parte late truncato cum verruca parva bidentatata et sub verrucam granulis minutis 3 ad marginem utrobique, ventre subconvexo cum granulis minutis 2 vel 3 ad marginen utrobique, polis inaequaliter biaculeatis, aculo superiori brevior quam inferiori; a vertice visis triangularibus, lateribus leviter retusis et glabris, angulis biaculeatis, seriebus tribus granulorum transverse dispositis, in centro cum annulo verrucarum bidenticulatarum 6. Long. cell. sine verr. 28 μ, cum verr. 30—31 μ, lat. sine acul. 31.5 μ, cum acul. 38.7 μ; lat. isthm. 11.7 μ.

KS185: C, rare.

This variety should be compared with *S. columbianum* Taylor, which is characterized by the angules of the semicells in distinctly prolonged short processes and the different ornamentations. It is closely allied to the preceding variety, but it differs from the latter in having different ornamentations and somewhat dissimilar outline of the semicells in both front and end views.

STAURASTRUM GEMELLIPARUM Nordst., Vidensk. Medd. f. d. naturh. Foren. i. Kjöbenhavn 1869: 230, pl. 4, fig. 54. 1869.

Forma paullo major, semicellulis a vertice visis quadrangularibus. Long. cell. sine proc. 29.7 μ, cum proc. 34.2 μ, lat. sine proc. 31.5 μ, cum proc. 36 μ; lat. isthm. 13.5 μ; long. spin. 2—3 μ.

KS192 and *KS201,* rare.

STAURASTRUM HEXACERUM (Ehr.) Wittr., Bih. t. k. Vet.-Akad. Handl. 1: 51. 1872; W. and G. S. West and Carter, Monogr. Brit. Dèsm. 5: 138, pl. 142, figs. 11—14. 1923. Long. cell. 27 μ, lat. sine spin. 29.7—31.5 μ cum spin. 31.5—32.5 μ; lat. isthm. 9 μ; *KS75,* scarce.

STAURASTRUM INDENTATUM W. et G. S. West, Trans. Linn. Soc. London, Ser. 2, Bot. 6: 186, pl. 22, figs. 10—12. 1902. (Fig. 5, *1*)

Long. cell. 42.3 μ, lat. cum. proc. 79 μ; lat. isthm. 8.1 μ.

KS185: C, fairly common.

This species has previously been recorded only from Ceylon. The Chinese plant is typical.

STUARASTRUM KWANGSIENSE, sp. nov. (Fig. 5, *11*)

S. submagnum, circiter 1.5-plo latius quam longum (cum processibus), modice constrictum, sinu aperto subrotundato; semicellulis a fronte visis late obcuneatis, base rotundatis, angulis superioribus in processus longos gradatim attenuatos horizontaliter dispositos productis, maginibus superioribus inferioribusque processuum et lateribus semicellularum verrucis numerosis truncato-emarginatis ornatis, sed verrucis in extremite processuum minoribus et papilliformibus (non truncato-emarginatis), inter marginem

superiorem inferioremque processuum serie verrucarum similarum instructis, apicibus processuum quadridentatis, apicibus semicellularum subtruncatis et glabris; a vertice visis triangularibus, lateribus levissime concavis, angulis in processus longos productis, margine et intra marginem verrucis truncato-emarginatis instructis. Long. cell. 45—50 μ, lat. cum proc. 75—78 μ; lat. isthm. 10—11 μ.

KS185: C, fairly rare.

In 1892, Turner based upon one of Joshua's drawings and a part of his diagnosis of *Staurastrum bifurcum* Josh. (Ann. and Mag. Nat. Hist. 3: 642, pl. 23, fig. 27. 1885) he established a new species of *Staurastrum, S. Burmense,* with two rough figures but without diagnosis (K. Sv. Vet.-Acad. Handl. 25: 28, pl. 16, fig. 13. 1892). Comparing Turner's figures of *S. Burmense* with the characteristics of the present new species, they are, however, very closely allied to each other, but the second differs from the first in having different shape of the semicells in the front view and that the processes provide an entirely dentate lower margin and a partly dentate and partly warty upper margin.

STAURASTRUM LEPTODERMUM Lund., Nova Acta reg. Soc. Scient. Upsala, Ser. 3, 8: 58, pl. 3, fig. 26. 1871. (Fig. 4, *7*)

Long. cell. sine spin. 55.8 μ, cum spin. 63 μ, lat. sine spin 57.6 μ, cum spin. 63 μ; lat. isthm. 19 μ; long. spin. 3—4 μ.

KS185: C, scarce.

Typical form of this species has not previously been recorded from China.

STAURASTRUM LONGIROSTRATUM Grönb. var. sinense, var. nov. (Fig. 4, *19*)

Var. minor, semicellulis a fronte visis subfusiformibus, utroque fine in spinam validiorem horizontaliter productis, angulis subacutis; spinis longitudine aequilibus. Long. cell. sine spin. 32.4—38.7 μ, lat. sine spin. 35—38 μ, cum spin. 46.8—50.5 μ, cum spin. 52—55 μ; lat. isthm. 12.6 μ; long. spin. 10—11 μ.

KS119, rare; *KS185: C,* scarce.

This alga bears some resemblance to *S. setigerum* Cleve, *S. sagittiferum* Börg., and *S. villosum* W. et G. S. West. It differs from them chiefly in having spines regularly arranged in rows, a smooth triangular area appearing constantly in the centre of the semicells in the vertical view, and a single stout spine on the apex of each angule of the semicells. These characteristics indicate that it is closely allied to *S. longirostratum.* It should also be compared with *S. gladiosum* Turn. var. *longispinum* Turn., which has a different shape of the semicells and dissimilar arrangement of the spines.

STAURASTRUM MICRON W. et G. S. West forma W. et G. S. West, Bot. Tidsskr. 24: 95, pl. 3, fig. 38. 1901. (Fig. 4, *6*)

Long. cell. 16—17 μ, lat. 20—21 μ; lat. isthm. 5.4 μ.

KS185: C, rare.

The Chinese plant agrees fairly well in all respects with a Siamese form of this species described by Wests, except that the minute spines on each process are in four series.

This species has not previously recorded from China.

STAURASTRUM MUCRONATUM Ralfs var. MAJOR, var. nov. (Fig. 4, *1*)

Var. major, angulis semicellularum acute rotundatis, breviter spinulosis. Long. cell. 34—35 μ, lat. sine spin. 37 μ; lat. isthm. 9 μ; long. spin. 1 μ.

KS137, rare.

In size, this variety is nearest to *S. mucronatum* var. *subtriangulare* W. et G. S. West, but the semicells of the latter are characterized by its dorsal margin in being nearly straight or slightly convex and the ventral margin in being nearly semicircular in outline.

STAURASTRUM MUTABILE Turn. var. GRANULATUM, var. nov. (Fig. 5, *2*)

Var. semicellulis a vertice visis 3- vel 5-angularibus, intra marginem granulis (non aculeis) 3- vel 5-angulatim (non circulatim) ordinatis ornatis. Long. cell. 26—28 μ, lat. 27—33 μ; lat. isthm. 8.0—12.5 μ.

KS137, rare; *KS201,* fairly common.

Turner mentioned in his description of this alga that the semicells of this species when viewed vertically are "5—7-gonum, . . . medio aculeis parvis (2 quumque appositis) circulatim ordinatis instructum" (K. Sv. Vet.-Acad. Handl. 25: 129. 1893). These characteristics are, however, different from those of the new variety.

This species has previously been recorded from India and Africa.

STAURASTRUM MUTICUM Bréb. *in* Menegh., Synops. Desm. 228. 1840; Ralfs, Brit. Desm. 125, pl. 21, fig. 4; pl. 34, fig. 13. 1848.

Long. cell. 27 μ, lat. 22.5 μ; lat. isthm. 9 μ..

KS201, fairly common.

STAURASTRUM ORBICULARE Ralfs var. RALFSII W. et G. S. West, Monogr. Brit. Desm. 4. 156, pl. 124, figs. 12, 13, 15, and 16. 1912. (Fig. 4, *16*)

Long. cell. 32.4—33.3 μ, 25.2—27.0 μ; lat. isthm. 7.2—8.1 μ.

KS192, rather common.

The Chinese plant is typical. In Asia, this species has previously been recorded from India. It is widely distributed in both America and Europe.

STAURASTRUM PINNATUM Turn. var. SUBPINNATUM (Schmidle) W. et G. S. West, Trans. Linn. Soc. London, Ser. 2, Bot., 6: 182, pl. 21, fig. 33. 1902; Borge, Ark. Bot. 7: 10, pl. 1, fig. 9. 1909. (Fig. 4, *20*)

Staurastrum subpinnatum Schmidle, Flora 82: 311, pl. 9, fig. 20. 1896.

Long. cell. 23.5—29.5 μ, lat. 38—45 μ; lat. isthm. 8—9 μ.

KS185: C, rather rare.

From the writer's point of view, all drawings of this variety given by former algologists seem to be not quite accurate and not detailed enough, therefore the writer takes the Chinese plant as the typical form of this variety, and detailed drawings in three views are made. The apex of the semicells of this plant is truncate and only very slightly elevated from the base of the radiate processes. In the individuals with five radiate processes, the basal portion of the semicells is furnished with fourteen granules just above the isthmus. Each process ends in four short spines. The "verrucae", so called by Wests (loc. cit.), arising from the upper side of the base of the processes are generally placed horizontally or a little downward, terminating in five minute spines,

possessing a single ring of obtuse minute teeth, and with a single similar tooth on one side of their base. These features are, however, mostly similar to those of the processes of the semicells. According to the structure of this kind of "verrucae", the writer suggestes that such "verrucae" is better to be termed "corniculae".

This variety, as well as the species, has not previously been recorded from China.

STAURASTRUM PUNCTULATUM Bréb. var. SUBFUSIFORME, var. nov. (Fig. 4, *3*)

Var. semicellulis a fronte visis triangulari-fusiformibus, apicibus lateribusque levissime convexis, angulis subacute rotundatis; a vertice visis lateribus distincte retusis. Long. cell. 27 μ, lat. 33.5 μ; lat. isthm. 9 μ.

KS185: C, rare.

This variety should be compared with *S. punctulatum* var. *ellipticum* Lewin, in which the semicells are elliptical in the front view and with the nearly straight side in the vertical view.

STAURASTRUM PUNCTULATUM Bréb. var. TRIANGULARE, var. nov. (Fig. 4, *2*)

Var. semicellulis a fronte visis triangularibus, apicibus truncatis vel interdum levissime convexis, lateribus fere rectis, angulis rotundatis; a vertice visis lateribus concavis, angulis rotundatis. Long. cell. 30 μ, lat. 29.5—31.5 μ; lat. isthm. 10 μ.

KS185: C, scarce.

This plant differs from the preceding variety in having semicells with a truncate apex and the more rotund angles.

STAURASTRUM QUADRICORNUTUM Roy et Biss. var. PARTENS W. et G. S. West, Trans. Linn. Soc. London, Ser. 2, Bot., 6: 179, pl. 21, fig. 24. 1902. (Fig. 4, *22*)

Forma major, semicellulis a vertice visis 4-radiatis, lateribus valide concavis. Long. cell. sine proc. 25—27 μ, cum proc. 38.5—39.5 μ, lat. sine proc. 25—26 μ, cum proc. 41.5—49.5 μ; lat. isthm. 11.5—12.5 μ; long. proc. sine spin. 5—9 μ, cum spin. 8—12 μ.

KS185: C, scarce.

This variety, as well as the species, has not previously been recorded from China.

STAURASTRUM RETUSUM Turn., K. Sv. Vet.-Acad. Handl. 25: 104, pl. 13, fig. 13. 1893. (Fig. 4, *12* & *13*)

Long. cell. 22.5—26.2 μ, lat. 22.5—26.2 μ; lat. isthm. 7.2—9.9 μ.

KS192, scarce.

In the original diagnosis of this species given by Turner (loc. cit.), the cell wall is described as "glabrae ?". In the Chinese plant, the cell wall is absolutely smooth. Turner's specimens may also be provided with similar cell walls.

This is one of the oriental species, that has not previously been recorded from China.

STAURASTRUM RETUSUM Turn. var. PUNCTULATUM Eichler et Gutw., Rozpraw. Wydz. Akad. Umiej. Krakow 1894: 174, pl. 5, fig. 44. 1895. (Fig. 4, *14*)

Long. cell. 23 μ, lat. 23 μ; lat. isthm. 5.4 μ.

KS185: C, scarce.

W. and G. S. West stated that "the cell wall (of this variety) is minutely punctulate all over, the punctations being more marked at the angles, and in many cases the angles

are distinctly thickened" (Trans. Linn. Soc. London, Ser. 2, Bot., 6: 178. 1902). These facts agree entirely with those of the Chinese plant. As Wests did not find the typical form of the species from Ceylon, they said that "it is highly probable that the variety *punctulatum* is identical with the typical form, as Turner's description of Wallich's figure is not definite as implied by the expression "glabrae ?", and probably Wallich's figure is not good". According to the writer's samples, the individuals either with a punctate or with a smooth wall are found in different samples collected from different localities. Thus, the variety *punctulatum* can not be considered as a synonym of the species.

STAURASTRUM SEXANGULARE (Bulnh.) Lund., Nova Acta reg. soc. scient. Upsala, Ser. 3, 8: 71, pl. 4, fig. 9. 1871; W. and G. S. West and Carter, Monogr. Brit. Desm. 5: 194, pl. 157, figs. 2 and 3. 1923. (Fig. 6, 9)

Long. cell sine proc. 43.2 μ, cum proc. 64.8 μ, lat. sine proc. 45—47 μ, cum proc. 92—95 μ; lat. isthm. 16.2 μ.

KS185: C, common.

According to the diagnosis of this species given by Lundell, the semicells viewed vertically are characterized by "inter angulos retusae et (intra marginem) granulis nonnullis ornatae" (loc. cit.). These granules shown in Lundell's drawings are five to six in number just within each retuse portion of the apex of the semicells. According to the diagnosis and drawings given by later workers, such as W. and G. S. West and Carter (loc. cit.), there is only a pair of granules within each retuse portion of the margin. The type of granulation in the Chinese plant is, however, in agreement with Wests' and Carter's description and drawings, but does not agree with the original diagnosis and drawing given by Lundell.

The typical form of this species has not previously been recorded from China.

STAURASTRUM SEXANGULARE (Bulnh.) Lund. var. ASPERUM Playf., Prod. Linn. Soc. N. S. Wales 35: 489, pl. 12, fig. 13. 1910; Krieger, Arch. Hydrobiol. Suppl. 11: 206, pl. 17, fig. 2. 1932. (Fig. 6, *10*)

Long. cell. sine proc. 53—55 μ, cum proc. 88—90 μ, lat. sine proc. 50—54 μ, cum proc. 108—115 μ; lat. isthm. 20—22 μ.

KS185, scarce.

This variety differs from its type species in having punctate apex of the semicells and absence of the paired flattened granules within the lateral margin when the semicells is viewed vertically. Each semicell has seven or rarely six radiating processes. In the vertical view, the processes of the upper semicell are generally alternating with those of the lower one.

This variety has not previously been recorded from China.

STAURASTRUM SONTHALIANUM Turn., K. Sv. Vet.-Akad. Handl. 25: 124, pl. 14, fig. 27. 1893. (Fig. 5, *10*)

Long. cell. 37 μ, lat. cum proc. 67—68 μ; lat. isthm. 13.5 μ.

KS137, rather rare.

This species has not previously been recorded from China.

STAURASTRUM STRIOLATUM (Naeg.) Arch., 1861; W. and G. S. West, Monogr. Brit. Desm. 4: 177, pl. 127, figs. 1—5. 1912. (Fig. 4, *4*)

Forma semicellulis a fronte visis oblongis; sinu cellularum angustiori quam in forma speciei typica, extremo obtuso. Long. cell. 29 μ, lat. 28—31 μ; lat. isthm. 11 μ.

KS76, rather common; *KS192,* rare.

This species has not previously been recorded from China.

STAURASTRUM SUBAPICULIFERUM, sp. nov. (Fig. 5, *3*)

S. submagnum, circiter $1^1/_3$-plo latius quam longum (cum processibus), modice constrictum; semicellulis a fronte visis subcyathiformibus, apicibus levissime convexis verrucis magnis bi- vel tri-papillato-truncatis 4 ornatis, basi tumidis, sub processu unoqueque verrucis bigranulatis quadrate dispositis instructis, angulis superioribus in processus longos leviter incurvatos productis, marginibus superioribus inferioribusque processuum noduloso-verrucosis, verrucis in parte basali processuum majoribus bi- vel tri-papillato-truncatis, in parte apicali minoribus truncatis vel obtusis, apicibus processuum quadridentatis, membrana inter processus cum serie spinarum parvarum 4; a vertice visis triangularibus, lateribus rectis incrassatis quadridentatis, angulis in processus longos 7-nodulosos productis, intra marginem lateralem unumquemque verrucis bi- vel tri-papillato-truncatis 4, ad basim processus verrucis similibus 2 ornatis, inter margines processus cum serie verrucarum parvarum. Long. cell. sine verr. 50—52 μ, cum verr. 54—56 μ, lat. cum proc. 81—92 μ; lat. isthm. 16—17 μ.

KS185: C, scarce.

At first sight this alga looks like a form of *S. apiculiferum* Turn. With further observation the writer thinks that it should be determined as a new species. As stated by Turner, the processes of *S. apiculiferum* in both front and vertical views are "serrate striato-dentatis" (K. Sv. Vet.-Akad. Handl. 25: 127, 1893). In the new species, the processes are strongly nodulose-verrucose on both upper and lower margins in the front view of the semicell, and distinctly nodulose on both sides and only with a single longitudinal row of minute warts in their middle when viewed vertically. Furthermore, the semicells in the vertical view have the straight and distinctly thickened sides, and each side is furnished with four teeth. These characteristics do not agree with those of *S. apiculiferum.*

STAURASTRUM SUBAPICULIFERUM Jao var. UNDULATUM, var. nov. (Fig. 5, *4*)

Var. semicellulis a vertice visis lateribus 4-undulatis et non incrassatis, processibus brevioribus. Long. cell. sine verr. 50 μ, cum verr. 55 μ, lat. cum proc. 73 μ; lat. isthm. 14.4 μ.

KS192, scarce.

STAURASTRUM SUBCYCLACANTHUM, sp. nov. (Fig. 5, *6*)

S. subparvum, circiter 2-plo latius quam longum (sine spinis apicalibus processuum), modice constrictum; semicellulis a fronte visis obverse subsemicircularibus, angulis superioribus in processus longos leviter incurvatos productis, marginibus lateralibus semicellularum cum annulo granulorum actorum interrupto, marginibus inferioribus processuum dentibus 7 vel 8 ornatis, marginibus superioribus processuum in parte proxima

verrucis bidentatis (raro partim tridentatis) 3 et in parte medio dentibus truncatis 2 et in parte apicali spinis obtusis 3 instructis, apicibus processuum quadridentatis, apicibus semicellularum alte elevatis cum extemite ampliata truncata horizontaliter tridentato-verrucosa; a vertice visis triangularibus, lateribus glabris, levissime convexis, angulis in processus longos subnodulosos productis, in centro cum annulo verrucarum tridentatarum 6, ad basim processus uniucujusque verrucis bidentatis 2. Long. cell. 31—32 μ, lat. cum proc. 65.5—68.5 μ; lat. isthm. 8.5 μ

KS185: C, rather common.

In this species, the acute granules around the base of each semicell are twelve in number and every four of them arrange in a unit under each processes of the semicell. The apex of the semicell is practically an apical projection. In the front view, it has a height of 5—7 μ, a truncate and widely expanded apex with dentate warts, and storngly retuse sides. In the vertical view, it is circular in outline and with six tridentate warts on the edge. These warts are not really tridentate, invariably, two of the three teeth of each wart are generally united together from their base into a bifurcte structure, and the remaining one is isolated and widely separated from the other two.

This species is undoubtedly closely allied to *S. cyclacanthum* W. et G. S. West. It differs from the latter cheifly in having different shape of the semicells in the front view, longer processes, and especially the highly elevated apex of the semicells.

STAURASTRUM SUBCYCLACANTHUM Jao f. QUADRIDENTATUM, f. nov. (Fig. 5, *7*)

Forma verrucis apicalibus quadridentatis; ceterum ut in forma speciei typica. Long. cell. 33 μ, lat. cum proc. 69 μ; lat. isthm. 8.5 μ.

Associated with the type species, rare.

STAURASTRUM SUBCYCLACANTHUM Jao var. MIRIFICUM, var. nov. (Fig. 5, *8*)

Var. semicellulis in fronte visis fere cyathiformibus, apice modice elevatis, basi tumidis, supra isthmum et infra basin processus verruca emarginata et juxta verrucam utrinque granulo minuto instructis, processibus brevioribus et leviter extrorsum curvatis, ad basin superiorem verrucis tridentatis 3 instructis. Long. cell. 28.8 μ, lat. cum proc. 50—54 μ; lat. isthm. 6.5 μ.

Associated with the type species, scarce.

This variety differs from the typical form of this species chiefly in having different ornamentations on the base of the semicells and on the upper side of the base of the processes, as well as in having comparatively shorter and slightly outwardly curved processes.

STAURASTRUM TOHOPEKALIGENSE Wolle var. QUADRIDENTATUM, var. nov. (Fig. 6, *12*)

Var. semicellulis a fronte visis depresso-globosis, apicibus levissime convexis vel subrectis, processibus paullo brevioribus, apice processuum 4-denticulatis, dentibus latissime divergentibus. Long. cell. sine proc. 37.8 μ, cum proc. 59.4 μ, lat. sine proc. 28 μ, cum proc. 45 μ; lat. isthm. 15.5 μ; long. spin. 4.5—6.5 μ.

KS137, rare; *KS185:* C, scarce.

In this species, the vertically disposed teeth on the apex of the processes are always longer than those placed transversely.

STAURASTRUM TOHOPEKALIGENSE Wolle var. TRIFURCATUM W. et G. S. West, Trans. Linn. Soc. London, Ser. 2, Bot., 5: 80, pl. 9, fig. 8. 1895. (Fig. 6, *11*)

Forma semicellulis a vertice visis circulari-triangularibus, dentibus processuum brevioribus quam in forma typica. Long. cell. sine proc. 37.8 μ, cum proc. 51.3—52.2 μ; lat. sine proc. 26—28 μ, cum proc. 40.5—47.7 μ; lat. isthm. 17 μ.

KS75, rather rare.

This Chinese alga seems to be very closely allied to *S. Arctiscon* (Ehr.) Lund. var. *brevibrachiatum* Borge. As its semicells in the vertical view are somewhat triangular in outline, not really 9-angular, it may be better referred to *S. Tohopekaligense* var. *trifurcatum* as a form.

W. and G. S. West mentioned that on each semicell the number of the processes of *S. Tohopekaligense* and its var. *trifurcatum* may be either nine or fifteen (Trans. Linn. Soc. London, Ser. 2, Bot., 6: 180 and 181. 1902). In the preceding new variety and the form, the total number of processes on each semicell is uniformly fifteen.

STAURASTRUM VERRUCIFERUM, sp. nov. (Fig. 4, *21*)

S. submagnum, circiter $1^1/_3$-plo latius quam longum (cum processibus), modice constrictum, sinu aperto; semicellulis a fronte visis rectangularibus, angulis superioribus subrectangularibus, inferioribus subrotundatis, lateribus in processus breves validos horizontaliter productis, apicibus semicellularum truncatis leviter elevatis cum verrucis magnis sed brevibus trigranulato-truncatis juxta et infra marginem, ad basin semicellularum sub processu unoquoque denticulo obtuso instructis, marginibus superioribus inferioribusque verrucosis, verrucis emarginatis bigranulatisque, intra margines processus verrucis similibus in series verticales 2 vel 3 ordinatis instructis, apicibus processuum truncatis quadridentatisque; a vertice visis quadrangularibus, lateribus concavis, angulis in processus breves validos productis, processibus cum seriebus verrucarum emarginatarum bigranulatarum transverse dispositis 2 vel 3, in centro semicellularum cum annulo verrucarum magnarum trigranulatarum 8. Long. cell. 50—51 μ, lat. cum proc. 52—53 μ, lat. isthm. 13.5 μ.

KS201, rare.

The writer knows no other species of *Staurastrum* with the semicells being rectangular in the front view and the processes embracing two or three rings of bigranulate and emarginate warts encircling each process, so that he recognizes this alga as a new species.

EUASTRUM Ehr.

EUASTRUM ANSATUM Ralfs, Brit. Desm. 85, pl. 14, fig. 2. 1848.

Long. cell. 76—90 μ, lat. 40—49 μ, crass. 27—33 μ ; lat. lob. polar. 20.0—22.5 μ. lat. isthm. 13—14 μ.

KS75, KS112, and *KS119,* fairly common.

EUASTRUM CAPENSE Fritsch var. ORIENTALE, var. nov. (Fig. 7, *2*)

Var. minor, semicellulis dentibus minutis 3 intra marginem lateralem et dentibus similibus 6 intra marginem apicalem instructis; a latere visis longitudinaliter depresso-

globosis, tumore nullis; a vertice visis exacte obovoideis, polis dentibus minutis 2 instructis. Long. cell. 26—29 μ, lat. 18—20 μ, crass. 15 μ; lat. isthm. 6 μ.

KS75, fairly rare.

The shape of the cells of this new variety is entirely similar to that of its type species in the front view, but not in the lateral and vertical views. In the type species, there are two or three rows of granules within both lateral and polar lobes; while in this new variety, there is, however, only a single row of twelve minute teeth within these lobes.

Euastrum denticulatum (Kirchn.) Gay, Bull. Soc. Bot. France, 31: 335. 1884. (Fig. 7, *7*)

Euastrum binale (Turp.) Ehr. var. *denticulatum* Kirchi. *in* Cohn, Krypt.-Fl. Schlesien, 159. 1878.

Forma lobis lateralibus apice divergentibus; membrana intra marginem loborum lateralis granulis 2 et intra marginem lobulorum polarum granulis 4 ornata; semicellulis a vertice visis obovoideis, polis rotundatis; a latere visis apice rotundatis. Long. cell. 22.5 μ, lat. 16 μ, crass. 19 μ; lat. isthm. 3.6 μ.

Euastrum didelta (Turp.) Ralfs var. sinicum, var. nov. (Fig. 6, *6*)

Var. paullo minor, angulis basalibus semicellularum subrectangularibus, cum scrobiculis magnis profundissimis binis verticaliter dispositis in centro semicellularum. Long. cell. 120—130 μ, lat. 70—72 μ, crass. 40—42 μ; lat. lob. polar. 28—30 μ; lat. isthm. 16.0—17.5 μ.

KS75, scarce.

This variety should be compared with *E. sinuosum* Lenorm. var. *ceylanicum* W. et G. S. West. It differs from the latter in having different shape of the semicells in the front view, different outline of the polar lobe in the vertical view, and greater dimensions of the cells. These distinctive peculiarities show that this Chinese alga should be referred to *E. didelta* as a new variety and can not be determined as a variety of *E. sinuosum* or as a form of *E. sinuisum* var. *ceylanicum*.

Unfortunately, W. and G. S. West did not describe or show the shape of the polar lobe of *S. sinuosum* var. *ceylanicum* in the vertical view either in their original diagnosis or in their drawings (Trans. Linn. Soc. London, Ser. 2, Bot., 6: 148, pl. 19, fig. 16. 1902). If its polar lobe in the vertical view is similar to *S. didelta* or the present new variety in outline, it seems to be that it is more closely allied to *S. didelta* rather than *S. sinuosum*.

Euastrum divergens Jash., Journ. Linn. Soc. Bot. 21: 640, pl. 23, fig. 8 and 9. 1886. (Fig. 7, *16*)

Forma paululo major, sinu cellularum intus angusto-lineari, extus amplicto; semicellulis supra isthmum annulo granulorum 8—9 et intra annulum granulis 2 instructis, lobulis superioribus loborum lateralium apice longe quadridentatis, illis inferioribus apice longe tridentatis, lobo polari infra marginem dentibus 6 ornato; a vertice visis elliptico-fusiformibus, utroque polo subacuminatis, medio utrinque valde inflatis tumore granulato praeditis, lobo polari quadrato; a latere visis ovatis, utrinque tumore basali magno praeditis, apice late truncatis et levissime retusis; pyrenoidibus

binis; ceterum ut in forma speciei typica. Long. cell. 53—58 μ, lat. cum proc. 47—55 μ, cum proc. et spin. processuum 52—59 μ, crass. 22—27 μ; lat. lob. polar. cum spin. 20—21 μ, sine spin. 15—16 μ; lat. isthm. 12.5—13.5 μ.

KS119 and *KS137,* fairly common; *KS157,* common.

Jashua's original diagnosis and drawings of this species are confined to the front view of the cells. The characteristics mentioned in his diagnosis are not in detail (loc. cit.). Under these conditions, the writer does not think that the Chinese plant is really the typical from of this species. Comparing the characteristics of the Chinese plant given above with those shown in Jashua's diagnosis and drawings of this species, significant variations observed in the Chinese plant are the type of the sinus of its cells and the structure of its central tumour.

This Chinese plant should also be compared with *E. divergens* var. *australianum* Borge and another variety of the same species, var. *ornatum* (Borge) Schmidle. It differs from them chiefly in having different type of the sinus of its cells, dissimilar ornamentations on its cell wall, and peculiar shape of its semicells especially in the vertical view.

The typical form of this species has previously been recorded from Burma.

EUASTRUM DUBIUM Naeg. var. KWANGSIENSE, var. nov. (Fig. 7, *4*)

Var. lobo polari profunde inciso, angulis in aculeum acutum breviter productis; membrana supra isthmum et prope medio semicellularum tumore biverrucoso magno et intra marginem loborum lateralium et lobulorum polarum tumore singulo parvo instructa; semicellulis a vertice visis ellipticis, polis rotundatis, tumoribus tribus utrobique, tumoribus centralibus non oppositis; a latere visis subovatis, tumore magno prope basin, apice subtruncatis et leviter dilatatis. Long. cell. 31—32 μ, lat. 20—22 μ. crass. 18 μ; lat. isthm. 4.5 μ.

KS187: C, rare.

Only a few individuals of this variety are found in this sample. Generally, the central tumour of one of the semicells is not opposite to that of the other. This is one of the distinctive characteristics of this variety.

This variety possesses some characteristics of both *E. dubium* var. *ornatum* Wolosz. and var. *tropicum* (W. et G. S. West) Krieger. As it has the prominent central tumours, it is more closely related to the second variety.

EUASTRUM FISSUM W. et G. S. West var. KWANGSIENSE, var. nov. (Fig. 7, *13*)

Var. sinu cellularum extremo non ampliato; lateribus semicellularum infra partem retusam rotundatis, incisura mediana apicali subaperta; membrana intra marginem apicalem utrobique granulo hemisphaerico et intra marginem lateralium utrobique tumoribus binis biverrucosis instructa; ceterum ut in forma speciei typica. Long. cell. 35 μ, lat. 20 μ, crass. 15.3 μ; lat. isthm. 4.5 μ.

KS185: C, scarce.

This species was first recorded by W. and G. S. West from Ceylon (Trans. Linn. Soc. London, Ser. 2, Bot., 4: 154. 1902). It differs from the new variety in having only a single granule within the lateral margin of each semicell, a narrowly linear apical

incision, a sinus with a dilated extremity, and nearly straight lateral margins below the lateral notches.

EUASTRUM GAYANUM De Toni forma Groenb., Act. Soc. Fauna Fl. Fennica 47: 13, pl. 3, figs. 12—15. 1921. (Fig. 7, *6*)

Long. cell. 13.5 μ, lat. 12.5, crass. 8 μ; lat. isthm. 3.6 μ.

KS75, rare.

The shape of the semicells and the type of granulation of the Chinese plant are identical with those of Grönblad's form, but the dimensions of the cells of the first are a little smaller than those of the latter.

This species has not previously been recorded from China.

EUASTRUM GNATHOPHORUM W. et G. S. West, Journ. Linn. Soc. Bot. 33: 160, pl. 9, figs. 3 and 4. 1897. (Fig. 6, *5*)

Forma maginibus lateralibus semicellularum in medio uniundulatis et membrana distincte incrassatis; verrucis basalibus semicellulae alterius collatis cum iis alterius. Long. cell. 64 μ, lat. 35 μ, crass. 23.5 μ; lat. isthm. 11 μ.

Associated with the preceding species, rare.

In the typical form of this species, the middle portion of the lateral margins of its semicells has two undulations, but there is no thickened node. The basal protuberances of one of the semicell are widely separated from those of the other. These features are, however, not similar to those of the Chinese form.

This species has previously been recorded from Singapore and Ceylon.

EUASTRUM INSULARE (Wittr.) Roy, Scott. Naturalist, April 1877; W. and G. S. West, Monogr. Brit. Desm. 2: 68, pl. 40, figs. 11—13. 1905. (Fig. 6, *8*)

Forma semicellulis a fronte visis angulis basalibus acutis. Long. cell. 29 μ, lat. 18 μ, crass. 13.5 μ; lat. isthm. 4.5 μ.

KS76, rare.

EUASTRUM PLATYCERUM Reinsch, Contrib. Alg. Fung, 1: 85, pl. 12, fig. 6. 1875. (Fig. 6, *3*)

Forma sinu cellularum angusto-lineari extremo levissime ampliato; semicellulis a fronte visis angulis inferioribus unidentatis, a vertice visis ellipticis, apice breviter spinosis, sub apice inflatis, medio utrobique tumore granulato praeditis; a latere visis subovatis tumore basali instructis, lateribus concavis, apice rotundatis. Long. cell. 42 u, lat. 38—42 μ, crass. 21.5—22.5 μ; lat. lob. polar. 12.5—14.5 μ; lat. isthm. 10.8 μ.

KS76, fairly common.

This form should be compared with *E. bellum* Nordst. var. *madagascariense* W. et G. S. West, as it has the lateral lobes not distinctly erect-patent and comparatively narrower but longer polar lobe with a truncate apex.

Euastrum bellum var. *madagascariense* has been recorded from Chengku, Shensi, by the writer in 1948 (Bot. Bull. Acad. Sinice 2: 57, fig. 3, *f*. 1948). It should be considered as one of the samples of this present form.

EUASTRUM PLATYCERUM Reinsch var. ORNATUM, var. nov. (Fig. 6, *1*)

Var. sinu cellularum angusto-lineari extremo levissime ampliato; lobis lateralibus levissime erecto-patentibus, lateribus inferioribus distincte divergentibus; spinis loborum validioribus et obtuso-conicis; membrana semicellularum in isthmo granulo magno hemisphaerico ornata, tumoribus intra lobum lateralem nulla; semicellulis a vertice visis ellipticis, polis rotundartis et granulatis, tumore magno ad medium utrobique, lobo polari quadrato; a latere visis subovatis, apicibus late rotundatis, tumore magno ad basin utrobique. Long. cell. 46—52 μ, lat. 43—45 μ, crass. 23—25 μ; lat. lob. polar. 13.5—15.5 μ; lat. isthm. 9—11 μ.

KS76, KS137, and *KS157,* fairly common.

This variety should be compared with *E. bellum* Nordst. var. *madagarscariense* W. et G. S. West. As it has the shorter but wider polar and lateral lobes, it is better to be determined as a new variety of *E. platycerum.*

EUASTRUM PLATYCERUM Reinsch var. SINICUM, nob. (Fig. 6, *4*)

Euastrum sphyroides Nordst. var. *sinicum* Jao, Sinensia 11: 311, pl. 6, fig. 2. 1940.

Var. sinu semicellularum angusto-lineari extremo levissime ampliato; lobis lateralibus semicellularum erecto-patentibus vel fere horizontalibus, lateribus inferioribus distincte divergentibus, spinis obtuse conicis in series verticales dispositis, tumoribus nullis. Long. cell. 45—46 μ, lat. 41—43 μ, crass. 23—24 μ; lat. lob. polar. 14.5—16.0 μ; lat. isthm. 10 μ

KS192, fairly common; *KS194,* scarce.

The Chinese plant bears some resemblance to both *E. platycerum* Reinsch and *E. sphyroides* Nordst. To the writer, it seems that this alga may be referred to either of these two species as a variety. As the lateral lobes of the semicells are slightly erect-patent and with a distinct divergent lower side, it is more closely allied to *E. platycerum.*

EUASTRUM PLESIOCORALLOIDES W. et G. S. West var. SINENSE, var. nov. (Fig. 7, *1*)

Var. lobis lateralibus angulo inferiore lobulorum superiorum et illo superiore lobulorum inferiorum obtusis; lobo polari apice truncato, insura mediana subaperto, angulis superioribus inferioribusque spina valida ornato; tumoribus omnibus verrucosis; scrobiculis in centra semicellularum nullis; granulis intra marginem loborum lateralium polariumque majoribus; ceterum ut in forma speciei typica. Long. cell. 33.5 μ, lat. 26 μ, crass. 16 μ; lat. isthm. 6.3 μ.

KS185: C, rare.

This variety should be compared with *E. Turnerii* West and *E. coralloides* Josh. var. *trigibberum* Lagerh. It differs from them collectively in having deeper but narrower lateral incisions, different form of the polar lobe, and dissimilar ornamentations on the cell wall, and especially from the first in having rotund poles of the semicells in the vertical view.

E. plesiocoralloides has been recorded only from Ceylon.

EUASTRUM QUADRATUM Nordst. var. JAVANICUM Nordst., Act. Univ. Lund. 16: 9, pl. 1, fig. 15. 1880. (Fig. 7, *12*)

Forma cellulis a fronte visis subquadrangulari-circularibus, lobulo loborum lateralium et lobo polari apice distincte emarginati, intra angulum lobi polaris et intra maginem

lobulorum lateralium verruca tridentata et tumore parvo infra verrucam instructo; ad basin loborum lateralium cum tumoribus minutis 3 verticaliter ordinatis; semicellulis a vertice visis polis anguste truncatis. Long. cell. sine spin. 59—63 μ, cum spin. 65.5—67.5 μ, lat. sine spin. 54—57 μ, cum spin. 58.5—61.5 μ, crass. 31.5—36.0 μ; lat. lob. polar. sine spin. 21—25 μ, cum spin. 26—28 μ; lat. isthm. 13.5—14.5 μ.

KS119 and *KS337*, scarce; *KS157*, fairly common.

The Chinese plant seems to be closely allied to *E. quadrarum* var. *javanicum* f. *samoensis* Wille. It differs from the latter in having larger dimensions of the cells, emarginate apex of both polar lobe and lateral lobules, and a large tridentate wart appearing constantly within the angules of polar lobe and the apex of each lateral lobules. It should also be compared with *E. spinulosum* Delp. and its varieties and forms, but the latters are characterized by the rotund apex of both lower and upper lateral lobules and the absence of small tumours in both lateral lobules and polar lobe.

The typical form of this variety has not been recorded from China.

EUASTRUM SINUOSUM Lenorm.. *in* Ralfs, Brit. Desm. 85, pl. 13, figs. 5 a, b, and d. 1848; W. and G. S. West, Monogr. Brit. Desm. 2: 20, pl. 36, fig. 1. 1905. (Fig. 6, *7*)

Long. cell. 63 μ, lat. 40—42 μ, crass. 25 μ; lat. lob. polar. 18—20 μ; lat. isthm. 12 μ.

KS75, fairly common.

In the Chinese plant, each of the five protuberances possesses a conspicuous central scrobiculation, the upper angule of the lateral lobes of the semicells is also furnished with such a structure.

EUASTRUM SPICATUM Turn. var. WESTII, var. nov. (Fig. 6, *2*)

Euastrum spicatum Turn. forma W. et G. S. West, Trans. Linn. Soc. Bot. 6: 150, pl. 20, figs. 2 and 3. 1902.

Var. sinu cellularum angusto-lineari extremo ampliato; lobis lateralibus semicellularum apice rotundatis (non acute rotundatis); spinis loborum validioribus quam in forma typica, obtusis et irregulariter dispositis; semicellulis a vertice visis ellipticis, polis rotundatis et irregulariter spinosis, medio utrinque tumore magno verrucoso et prope polos utrobique tumore minore spinoso instructis; a latere visis subovatis, ad basin utrobique tumore verrucoso instructis, apice truncato dilatatoque. Long. cell. 69—72 μ, lat. sine spin. 54—58 μ, cum spin. 58—63 μ, crass. 32—33 μ; lat. lob. polar. sine spin. 22.5—23.5 μ, cum spin. 27—29 μ; lat. isthm. 13.5 μ.

KS75, rare.

W. and G. S. West have emphasized the significant variations of their form of *E. spicatum* Turn. from the typical form of the same. According to the writer's opinion, West's form can be considered as a new variety of Turner's species.

The Chinese plant agrees entirely in all respects with Wests' form found in Ceylon. This alga has not previously been recorded from China.

EUASTRUM SPINULOSUM Delp. subsp. AFRICANUM Nordst., Act. Univ. Lund. 16: 9, pl. 1, fig. 16, 1880. (Fig. 7, *10*)

Forma semicellulis a latere visis apice rotundatis. Long. cell. 65—68 μ, lat. 58—60 μ, crass. 38—40 μ; lat. isthm. 16.0—16.5 μ.

KS179 and *KS183*, scarce.

Judging from Nordstedt's original drawings of this subspecies (loc. cit.), the semicells in the lateral view have a truncate apex. This character is dissimilar to that of the Chinese plant.

EUASTRUM SPINULOSUM Delp. subsp. AFRICANUM Nordst. forma Borge, Bih. till K. Sv. Vet.-Acad. Handl. 24: 26, pl. 2, fig. 32. 1899. (Fig. 7, 9)

Long. cell. 70—73 μ, lat. 60—62 μ, crass. 35—38 μ; lat. isthm. 15—17 μ.

KS119 and *KS192*, fairly common.

Borge's form is characterized in having lesser spines, a rotund sinus between the lateral lobules, and an additional large granule on each side of the sinus of the cell. These characteristics of the Chinese plant are typical.

This form has not previously been recorded from China.

EUASTRUM SPINULOSUM Delp. subsp. INERMIUS Nordst., Act. Univ. Lund. 16: 9, pl. 1, fig. 17. 1880. (Fig. 7, *11*)

Long. cell. 52—53 μ, lat. 48—49 μ, crass. 25 μ; lat. isthm. 11 μ.

KS157 and *KS192*, scarce.

EUASTRUM STICTUM (Boerg.), nob. (Fig. 7, *3*)

Euastrum denticulatum (Kirchn.) Gay var. *stictum* Boerg., Vidensk. Medd. f. Naturh. Foren. 1890: 34, pl. 3, fig. 18. 1890.

Forma paullo minor; cellulis 1.5-plo longioribus; tumore centrali supra isthmum crasse 5-verrucoso (non granulato) et maiore quam in forma speciei typica; tumore minore 3-verrucoso utrobique juxta incisuram medianan loborum polarium; a verice visis late ellipticis, apice rotundatis et 5-undulatis; a latere visis apice distincte dilatatis et subconvexo-truncatis; ceterum ut in forma speciei typica. Long. cell. 33—34 μ, lat. 32—33 μ, crass. 17 μ; lat. isthm. 6 μ.

KS185: C, scarce.

Judging from the original diagnosis and drawing of *E. denticulatum* (Kirchn.) Gay var. *stictum* Boerg., it is distinctly distinguished from *E. denticulatum* (Kirchn.) Gay by the following characteristics: 1. The semicells have the rotund poles in the vertical view and a truncate apex with rotund angules in the lateral view. 2. There are two distinct protuberances within the apex of the semicells. Based upon these facts, Börgeson's variety may be better considered as an independent species.

EUASTRUM SUBHYPOCHONDRUM Fritsch et Rich var. SPICATOIDES, var. nov. (Fig. 7, *15*)

Var. circiter duplo-minor; sinu cellularum apice breviter lineari deinde subito ampliato, in media parte sine dente valido; lobo polari longiore, capitato-dilatato, apice concavo; spinis ad apicem loborum lateralium et ad angulos loborum polarium parcioribus quam in forma typica; tumore centrali cum verrucis in series duae, tumore laterali utrobique plane nullo.

Long. cell. sine spin. 58.5 μ, lat. sine spin. 55 μ, cum spin. 60—61 μ crass. 29 μ; lat. lob. polar. sine spin. 15.3 μ; lat. isthm. 11.7 μ.

KS119 and *KS121*, scarce.

Judging from the shape of the cells in all views, this species and the new variety

seem to be more closely related to *E. stellatum* Nordst. than to *E. hypochondrum* Nordst. They differ from the latter two chiefly in having more or less divergent lateral lobes and stronger spines on all lobes; and especially from the second in having a widely open sinus. They also bears some resemblance to *E. substellatum* Nordst., *E. bellum* Nordst., and *E. Hieronymusii* Schmidle. They differ from the first in having more or less divergent lateral lobes, different shape of the semicells in the vertical view, and stronger spines on all lobes; from the second in having a widely open sinus, a different shape of the cell in the vertical view, and short lateral lobes; and from the third in having a different shape of the sinus, elongated but proportionally narrower lateral lobes, and longer spines on all lobes. This new variety should also be compared with an oriental species, *Euastrum spicatum* Turn., but the latter has the horizontal lateral lobes and a less open sinus.

EUASTRUM SUBINSULARE, sp. nov. (Fig. 7, *5*)

E. parvum, circiter 1 $^2/_3$-plo longius quam latum, profundissime constrictum, sinu angusto-lineari extremo subampliato; semicellulis a fronte visis trilobis, incisuris lateralibus late rotundatis; lobis lateralibus brevibus, apice divergentibus et leviter retusis, angulis inferioribus subrectangularibus, superioribus rotundatis; lobo polari lato, apice late retuso et dilatato, angulis lateralibus rotundatis, infra marginem apicalem cum granulo magno; a vertice visis late ellipticis, granulo magno hemisphaerico intra maginem utrobique; a latere visis elliptico-oblongis, granulo magno hemisphaerico juxta angulum superiorem utrobique. Long. cell. 19 μ, lat. 12.6 μ, crass. 9 μ; lat. lob. polar. 10 μ, lat. isthm. 3 μ.

KS185: C, fairly common.

In the front view, this species is closely allied to *E. insulare* (Wittr.) Roy and *E. Cornubiense* W. et G. S. West. It differs from them chiefly in having a prominent protuberance near the apical margin of the polar lobe and a different shape of the semicells in both lateral and vertical views.

It seems to be that this species might be equally well considered as a member of *Cosmarium;* but on account of the retuse-emarginate apex of the semicells, it is better to include it as a species in the genus *Euastrum.* It is one of the connecting links between these two genera.

EUASTRUM SUBPICTUM, sp. nov. (Fig. 7, *14*)

E. submediocre, circiter 1 $^1/_3$-plo latius quam longum, profunde constrictum, sinu angusto-lineari extremo leviter ampliato; semicellulis pyramidato-quadratis, trilobis, incisuris lateralibus profundis subapertisque; lobis lateralibus subquadrato-trapeziformibus, marginibus lateralibus cum incisura mediana aperta sed non profunda; lobo polari brevi sed lato, superne valde dilatato, apice late rotundato cum incisura mediana profunda subaperta, lobulis cum incisura mediana aperta sed non profunda; lobulis loborum lateralium polariumque apice truncato-convexis, angulis denticulo singulo brevi instructis, denticulis similibus singulis vel binis in medio marginum apicalium ornatis; tumoribus magnis verrucosis (verrucis 5—7 peripherisis et 3—5 centralibus) 3 in serie transversa trans basin semicellularum, tumoribus similibus 2 intra lobum polarem; a vertice visis oblongo-ellipticis, polis rotundatis et breviter tridentatis, tumoribus

magnis prominentissimis 3 utrobique; a latere visis subovatis, apice truncato-convexis, tumore magno prominentissimo ad basin et tumore simili prope apicem utrobique; lobo polari semicellularum a vertice viso oblonge-elliptico, polis rotundatis et breviter tridentatis, tumoribus magnis prominentissimis 2 utrobique. Long. cell. 49—50 μ, lat. 38—39 μ, crass. 16 μ; lat. lob. polar. 29—30 μ; lat. isthm. 10 μ.

KS137, rare.

This species comes nearest to *E. pictum* Boerg. In the Chinese species, the semicells in the front view are practically four-lobed (two lateral lobes and two lobules of the polar lobe). The lateral lobes and the lobules of the polar lobe agree in all respects with one another. They have a slightly convex apex with an open median notch, the unidentate angules, one or two teeth on the middle of their apex, and a large tumour near the median notch. Moreover, the incision of the polar lobe is similar to that between the lateral and polar lobes in depth, width, and shape; and all tumours, including the central one, are also similar to one another in structure and size. The semicells and their polar lobe in the vertical view are oblong-elliptic in outline and with prominent tumours on both sides. These characteristics indicate that their Chinese alga should not be referred to *E. pictum* or considered as a variety or a form of the latter.

EUASTRUM SUBPORRECTUM, sp. nov. (Fig. 7, *8*)

E. mediocre, circiter 1 1/5-plo longius quam latum, profunde constrictum, sinu lineari extrosum ampliato; semicellulis a fronte visis profunde trilobis; lobis lateralibus apicibus rotundatis, granulis minutis 4—5 ad marginem apicalem et 4—5 intra illum instructis; lobo polari apice truncto levissime retuso, circa marginem apicalem granulis minutis circiter 6 utrobique; tumoribus minute concentriceque granulatis tribus in serie transversa trans basin semicellularum; supra isthmum cum granulo singulo; a vertice visis ellipticis, apice rotundatis, tumoribus tribus prominentis utrobique, lobo polari quadrato-oblongo; a latere visis ovatis, apice subtruncatis, lateralibus retusis; pyrenoidibus binis. Long. cell. 57.6 μ, lat. 45 μ, crass. 21.6 μ; lat. lob. polar. 15.3—16.2 μ; lat. isthm. 11.7 μ.

KS119, fairly rare.

In general appearance and size, this species comes nearest to *E. porrectum* Borge, but differs from the latter in having three large and granulated tumours across the base of the semicells, with the centre of the middle tumour not emarginate, granulate apex of the lateral and polar lobes, and a comparatively large granule in the middle immediately above the isthmus.

EUASTRUM VERRUCOSUM Ehr. var. ALATUM Wolle, Desm. U. S. 101, pl. 26, fig. 4. 1884.

Long. cell. 91—92 μ, lat. 76—77 μ, crass. 46 μ; lat. lob. polar. 35 μ; lat. isthm. 14.5 μ.

KS119, fairly common; *KS121,* scarce.

MICRASTERIAS Ag.

MICRASTERIAS ALATA Wall. Ann. Mag. Nat. Hist., Ser. 3, 5: 279, pl. 13, fig. 11. 1860; Wolle, Desm. U. S. 125, pl. 46, fig. 2. 1884. (Fig. 8, *8*)

Forma cellulis marjoribus quam in forma typica, sinu angusto-lineari extremo ampliato; semicellulis a latere visis subcylindricis, basi semicellularum et apice loborum polarium distincte tumidis, apicibus processuum breviter quadridentatis. Long. cell. 190—200 μ, crass. 25 μ, lat. 160—180 μ; lat. lob. polar. cum proc. 77—88 μ; lat. isthm. 15—20 μ.

KS185: C, scarce.

Judging from the original description and drawing of this species given by Wallich (loc. cit.), the sinus of the cells dilates slightly at its extremity, and the apex of the processes is tridentate. According to the drawing of the same taken from an Indian specimen by Wolle (loc. cit.), the sinus is open (not narrowly linear), and the apex of the processes is strongly bidentate. If Wallich and Wolle's observation is accurate, the Chinese plant is not typical.

This species has not previously been recorded from China.

MICRASTERIAS APICULATA (Ehr.) Menegh., 1840; W. and G. S. West, Monogr. Brit. Desm. 2: 97, pl. 47, figs. 1—2. 1905. (Fig. 8, *5*)

Long. cell. 237—258 μ, lat. 190—205 μ lat. isthm. 38 μ.

KS119, scarce.

As stated by Wests, each angle of the polar lobe is furnished "with a pair of diverging spines and with a large curved spine on the apical margin close to each angle" (loc. cit. 98). In the Chinese plant, the two diverging spines on the angles of the polar lobe become the short processes with a tridentate apex and the large curved spine close to the angle also becomes a short processes with bidentate apex.

MICRASTERIAS CRUX-MELITENSIS (Ehr.) Hass., Brit. Freshw. Alg. 386, pl. 90, fig. 7. 1845; W. and G. S. West, Monogr. Brit. Desm. 2: 116, pl. 53, figs. 1—3. 1905.

Long. cell. 110 μ, lat. 90 μ; lat. lob. polar. 38 μ; lat. isthm. 15 μ.

KS183, rare.

In the Chinese plant, the upper lateral lobules are mostly tridentate at the apex. This feature agrees with that of "*M. Crux-melitensis* var. *superflua* Turn.", which was considered as a synonym of the species by Wests (loc. cit.).

MICRASTERIAS DECEMDENTATA Arch. forma Borge, Ark. Bot. 1: 118, pl. 5, fig. 18. 1903. (Fig. 7, *17* & *18*)

Long. cell. 80—85 μ, lat. sine spin. 73—75 μ, cum spin. 75—85 μ, crass. 28—33 μ; lat. lob. polar. sine spin. 54—65 μ, cum spin. 56—75 μ; lat. isthm. 15—17 μ.

KS153, scarce.

The typical form of this species has two-lobed lateral lobes. In Borge's form, the lateral lobes are not distinctly two-lobed or only with an emarginate apex. In the Chinese plant, some individuals are similar to Borge's form in shape, but some others have a nearly straight apex of the lateral lobes. In size, the cell dimensions of the Chinese plant are greater than those given by Borge. According to former records of the species, it varies very often in dimensions.

MICRASTERIAS DENTICULATA Bréb. var. NOTATA Nordst., Bot. Notis. 1887: 155. 1887: K. Sv. Vet.-Akad. Handl. 22: 29, pl. 2, fig. 13. 1888.

Long. cell. 245—295 μ, lat. 195—275 μ; lat. lob. polar. 57—67 μ; lat. isthm. 25—30 μ.

KS11, rare; *KS185: C*, scarce.

MICRASTERIAS FOLIACEA Bail. *in* Ralfs, Brit. Desm. 210, pl. 35, fig. 3. 1848.

Long. cee. 70—75 μ, lat. 75—85 μ; lat. isthm. 16 μ.

KS119 and *KS185: C*, rare.

MICRASTERIAS MAHABULESHWARENSIS Hobson, 1863; Lund., Act. R. Soc. Scient. Upsala, Ser. 3, 8: 15, pl. 1, fig. 16. 1871. (Fig. 8, *2* & *3*)

Long. cell. 155—180 μ, lat. 113—145 μ, crass. cum tumor. basal. 28—30 μ; lat. lob. polar. cum proc. 80—105 μ; lat. isthm. 25—27 μ.

KS185: C, scarce.

As noted by W. and G. S. West (Monogr. Brit. Desm. 2: 122. 1905), that this species "is subject to great variation in the length of the processes, both of the polar and lateral lobes, in the amount of their divergence, and in the details of the surface-markings". These variations appear in the Chinese specimens also. The lobes and the processes of many individuals are elongated and narrow; those of some others are shorter and proportionally wider. In the latter case, the thickness of the cells is smaller than that of the typical form; and the apex of all processes are four- or five-toothed.

The typical form of this species has not previously been recorded from China.

MICRASTERIAS MOEBII W. et G. S. West var. JAVANICA Gutw., Bull. Acad. Crac. 1902: 603, pl. 40, fig. 58. 1902. (Fig. 8, *1*)

Long. cell. 118—119 μ, lat. 93—108 μ, crass. 58—60 μ; lat. lob. polar. 69—72 μ; lat. isthm. 37—40.5 μ.

KS119, rare.

The specimens collected from the above station correspond fairly well with those described by Gutwinski, but they differ from the latter in having different ornamentation of the central tumour. As shown in Gutwinski's drawings (loc. cit.), the central tumour is simply coarsely scrobiculate. In the writer's specimens, it is, however, in a regular arrangement of both scrobiculations and granules. The granules are disposed of in triangular form, and each granule is surrounded by six hexagonally arranged scrobiculations. The granules are similar to the scrobiculations in diameter. The writer thinks that the central tumour of Gutwinski's specimens agree entirely in structure to that observed by the writer, since the interlocated granules are easily mistaken as the scrobiculations.

This is the second discovery of this variety since Gutwinski described it from Java in 1902.

MICRASTERIAS PINNATIFIDA (Kuetz.) Ralfs, Brit. Desm. 77, pl. 10, fig. 3. 1848.

Long. cell. 65 μ, lat. sine spin. 60—67 μ, cum spin. 65—73 μ, crass. 18—20 μ; lat. lob. polar. sine spin. 40—47 μ, cum spin. 45—50 μ; lat. isthm. 12.6 μ.

KS185: C, KS192, and *KS201*, rare.

MICRASTERIAS RADIATA Hass., Brit. Desm. 386, pl. 90, fig. 2. 1845; W. and G. S. West, Monogr. Brit. Desm. 2: 113, pl. 52, figs. 1—9. 1905. (Fig. 8, *4*)

Forma lobo polari lateribus subconvexis, processibus brevioribus quam in forma typica; processibus lobulorum lateralium in parte basali plus minusve tumidis; semicellulis a vertice visis valde compressis, elongato-fusiformibus. Long. cell. 120—144 μ, lat. 110—144 μ, crass. 12—13 μ; lat. lob. polar. cum proc. 38—46 μ; lat. isthm. 16—17.5 μ.
KS185: C, rare.

MICRASTERIAS THOMASIANA Arch., 1862; W. and G. S. West, Monogr. Brit. Desm. 2: 110, pl. 51, figs. 3—6. 1905. (Fig. 8, *6* & *7*)

Apart from the typical form of this species, two abnormal ones were also found by the writer. The first has a very small middle projection on both sides of the isthmus (fig. 8, *7*). The second has five large projections across the base of each semicell and the sinus with a dilated basal portion. (fig. 8, *6*).

SPHAEROZOSMA Corda

SPHAEROZOSMA GRANULATUM Roy et Biss., Journ. Bot. 25: 242, fig. 17. 1886.
Long. cell. 10 μ, lat. 9 μ; lat. isthm. 3.6 μ.
KS185: C, rare.

DESMIDIUM Ag.

DESMIDIUM APTOGONUM Bréb., 1835; W. and G. S. West and Carter, Monogr. Brit. Desm. 5: 242, pl. 164, figs. 1—3. 1923.
Long. cell. 15—18 μ, lat. 29—30 μ; lat. apic. cell. 22.5—23.5 μ; lat. isthm. 24—25 μ.
KS119, KS121, and *KS183,* common.

DESMIDIUM BAILEYI (Ralfs) Nordst. var. COELATUM (Kirchn.) Nordst., K. Sv. Vet.-Akad. Handl. 22: 27, pl. 2, figs. 6 and 7. 1888.
Long. cell. 16—18 μ, lat. 27—28 μ; lat. isthm. 27 μ.
KS119, KS121, KS137, and *KS183,* fairly common.

DESMIDIUM SWARTZII Ag., 1824; Ralfs, Brit. Desm. 61, pl. 4. 1848.
Long. cell. 40—45 μ, lat. 16—18 μ; lat. apic. cell. 34—36 μ; lat. isthm. 31—33 .
KS121, scarce; *KS137,* rare; *KS180* and *KS183,* common.

HYALOTHECA Ehr.

HYALOTHECA DISSILIENS (Sm.) Bréb. f. CIRCULARIS Jacobs., 1875; W. and G. S. West and Carter, Monogr. Brit. Desm. 5: 232, pl. 161, fig. 19. 1923.
Long. cell. 13—23 μ, lat. 20—30 μ; diam. zygosp. 24 μ.
KS11 and *KS112,* common; *KS119* and *KS121,* scarce; *KS180,* fairly rare.

EXPLANATION OF FIGURES

Figure 1

1. *Pleurotaenium elatum* (Turn.) Borge, forma, × 366.
2. *Pleurotaenium Stuhlmannii* (Hieron) Schmidle, × 130.

3. *Pleurotaenium coronatum* (Bréb.) Rabenh. var. *nodulosum* (Bréb.) West, forma, × 360.
4. *Pleurotaenium parallelum* W. et G. S. West var. *undulatum* Borge, forma A, × 130.
5. *Plearutaenium parallelum* W. et G. S. West var. *undulatum* Borge, forma B, × 130.
6. *Pleurotaenium subundulatum* Borge var. *coroniferum* Borge, × 210.
7. *Pleurotaenium Kayei* Rabenh., × 210.
8. *Pleurotaenium ovatum* Nordst., × 130.
9, 10. *Closterium amphiceps*, sp. nov. Figure 9, × 130; figure 10, apex of the cell, showing the structure of the cell wall, × 366.
11, 12. *Closterium pseudonasutum*, sp. nov. (*11*), × 130; (*12*), apex of the cell, showing the structure of the cell wall, × 366.
13. *Closterium nematodes* Jash. var. *sinense*, var. nov., × 593.
14. *Closterium acerosum* (Schr.) Ehr. var. *kwangsiense*, var. nov., × 103.
15. *Penium spinospermum* Jash., × 593.
16—22. *Penium terrestre*, sp. nov., × 366. (*18*, *19*), zygespores in a front view; (*20*), the same in an end view; figures 21, 22, the same in a lateral view.
23. *Cosmarium rectangulare* Grun. var. *incrassatum*, var. nov., × 593.
24. *Cosmarium subtumidum* Nordst. var. *kwangsiense*, var. nov., × 593.
25. *Cosmarium Norimbergense* Reinsch., forma, × 593.
26. *Cosmarium Regnesi* Reinsch. var. *montanum* Schmidle, forma, × 593.
27. *Cosmarium succisum* West, forma, × 593.
28, 29. *Cosmarium spyridion* W. et G. S. West var. *subangulatum*, var. nov. (*28*), × 593; (*29*), central papilla in a front view, showing the structure, about × 1500.
30. *Cosmarium pseudadoxum*, sp. nov., × 593.
31. *Cosmarium contractum* Kirchn. var. *ellipsoideum* (Elfv.) W. et G. S. West f. *retusa* W. et G. S. West, forma, × 593.
32. *Cosmarium repandum* Nordst. f. *minor* W. et G. S. West, × 593.
33. *Cosmarium depressum* (Naeg.) Lund., forma, × 593.
34. *Cosmarium granatum* Bréb. var. *subhammerii*, var. nov., × 593.
35. *Cosmarium granatum* Bréb. var. *mirificum*, var. nov., × 366.
36. *Cosmarium polygonum* (Naeg.) Arch., × 593.
37. *Cosmarium umbilicatum* Luetk. var. *glabrum*, var. nov., × 593.
38. *Cosmarium Garrolense* Roy et Biss. var. *crassum*, var. nov., var. nov., × 366.
39. *Cosmarium bireme* Nordst., forma, × 593.

Figure 2

1. *Cosmarium reniforme* (Ralfs) Arch. var. *apertum* W. et G. S. West, × 593.
2. *Cosmarium creperum* W. et G. S. West var. *sinense*, var. nov., × 366.
3. *Cosmarium amoenum* Bréb. var. *Willei* (Turn.) nob., × 366.
4. *Cosmarium subspeciosum* Nordst. var. *simplicius*, var. nov., × 593.
5. *Cosmarium Turpinii* Bréb. var. *eximum* W. et G. S. West, forma, × 593.
6. *Cosmarium vexatum* West var. *sinense*, var. nov., × 593.
7. *Cosmarium bipunctatum* Boerg., forma, × 593.
8. *Cosmarium anisochondrum* Nordst., × 593.
9, 10. *Cosmarium subprotumidum* Nordst., × 593. (*10*), three central trumours in a front view, showing variations of the granulation.
11, 12. *Cosmarium ceylanicum* W. et G. S. West var. *sinicum*, var. nov. (*11*), × 593; (*12*), zypospores, × 366.
13. *Cosmarium cosmatiforme*, sp. nov., × 593.
14. *Cosmarium kwangsiense*, sp. nov., × 593.
15. *Cosmarium Blyttii* Wille var. *basiornatum*, var. nov., × 593.
16. *Cosmarium subauriculatum* W. et G. S. West var. *kwangsiense*, var. nov., × 366.
17. *Cosmarium globosum* Bulnh., forma, × 593.

18. *Cosmarium distichum* Nordst. var. *suboctogonum*, var. nov., × 593.
19. *Cosmarium hexapapillatum*, sp. nov., × 593.
20. *Cosmarium Lundelli* Delp. var. *corruptum* (Turn.) W. et G. S. West, forma, × 593.
21. *Cosmarium Lundellii* Delp. var. *pseudotuddalense*, var. nov., × 593.
22. *Cosmarium cyclicum* Lund. var. *sinense*, var. nov., × 593.

Figure 3

1. *Cosmarium Maculatum* Turn. var. *major*, var. nov., × 210.
2. *Cosmarium pseudoconnatum* Nordst. var. *subconstrictum*, var. nov., × 366.
3. *Cosmarium quadratum* Ralfs, forma, × 366.
4. *Arthrodesmus curvatus* Turn. var. *xanthidioides*, var. nov., × 366.

5, 6. *Xanthidium acanthophorum* Nordst. × 366. (*6*), different dispositions of the scrobiculations situated in the central thickened area of the semicells.

7. *Xanthidium Raciborskii* Gutw. var. *glabrum*, var. nov., × 366.
8. *Xanthidium subtrilobum* W. et G. S. West var. *Kriegerii*, var. nov., × 366.
9. *Xanthidium superbum* Elfv. × 366.
10. *Xanthidium Freemanii* W. et G. S. West, × 366.

11, 12. *Cosmarium Malivernianum* (Racib.) Schmidle var. *Badense* Schmidle f. *tropica* Gutw., × 593. (*12*), central area of a young semicell in a front view, showing the splitting of the ridges between the triangular depressions.

13. *Xanthidium antilopaeum* (Bréb.) Kuetz. var. *basiornatum* Echl. et Rac., forma, × 366.

Figure 4

1. *Staurastrum mucronatum* Ralfs var. *major*, var. nov.,. × 593.
2. *Staurastrum punctulatum* Bréb. var. *triangulare*, var. nov., × 593.
3. *Staurastrum punctulatum* Bréb. var. *subfusiforme*, var. nov., × 593
4. *Staurastrum striolatum* (Naeg.) Arch., forma, × 593.
5. *Staurastrum Dickiei* Ralfs var. *circulare* Turn., forma, × 593.
6. *Staurastrum micron* W. et G. S. West forma W. et G. S. West, × 593.
7. *Staurastrum leptodermum* Lund., × 593.
8. *Staurastrum aristiferum* Ralfs var. *projectum*, var. nov., × 366.
9. *Staurastrum contectum* Turn. var. *kwangsiense*, var. nov., × 593.
10. *Staurastrum contectum* Turn. var. *quadridentatum*, var. nov., × 593.
11. *Staurastrum contectum* Turn. *inevolutum* Turn., forma, × 593.

12, 13. *Staurastrum retusum* Turn., × 593.

14. *Staurastrum retusum* Turn. var. *punctulatum* Eichler et Gutw., × 593.
15. *Staurastrum ensiferum* Turn., forma, × 366.
16. *Staurastrum orbiculare* Ralfs var. *Ralfsii* W. et G. S. West, × 593.
17. *Staurastrum connatum* (Lund.) Roy et Biss. var. *rectangulum* Roy et Biss., forma, × 593.
18. *Staurastrum forficulatum* Lund. var. *ellipticum*, var. nov., × 593.
19. *Staurastrum longirostratum* Groenb. var. *sinense*, var. nov., × 593.
20. *Staurastrum pinnatum* Turn. var. *subpinnatum* (Schmidle) W. et G. S. West, × 593.
21. *Staurastrum verruciferum*, sp. nov., × 593.
22. *Staurastrum quadricornutum* Roy et Biss. var. *partens* W. et G. S. West, forma, × 593.

Figure 5

1. *Staurastrum indentatum* W. et G. S. West, × 593.
2. *Staurastrum mutabile* Turn. var. *granulatum*, var. nov., × 593.
3. *Staurastrum subapiculiferum*, sp. nov., × 593.
4. *Staurastrum subapiculiferum* Jao var. *undulatum*, var. nov., × 593.
5. *Staurastrum forficulatum* Lund. var. *simplicius*, var. nov., × 593.

6. *Staurastrum subcyclacanthum*, sp. nov., × 593.
7. *Staurastrum subcyclacanthum* Jao f. *quadridentatum*, f. nov., × 593.
8. *Staurastrum subcyclacanthum* Jao var. *mirificum*, var. nov., × 593.
9. *Staurastrum bicoronatum* Johnson var. *kwangsiense*, var. nov., × 593.
10. *Staurastrum Sonthalianum* Turn., × 593.
11. *Staurastrum kwangsiense*, sp. nov., × 593.
12. *Staurastrum excavatum* W. et G. S. West forma W. et G. S. West, × 593.

Figure 6

1. *Euastrum platycerum* Reinsch var. *ornatum*, var. nov., × 593.
2. *Euastrum spicatum* Turn. var. *Westii*, var. nov., × 366.
3. *Euastrum platycerum* Reinsch, forma, × 593.
4. *Euastrum platycerum* Reinsch var. *sinicum*, nob., × 593.
5. *Euastrum gnathophorum* W. et G. S. West, forma, × 593.
6. *Euastrum didelta* (Turp.) Ralfs var. *sinicum*, var. nov., × 366.
7. *Euastrum sinuosum* Lenorm., × 366.
8. *Euastrum insulare* (Wittr.) Roy, forma, × 593.
9. *Staurastrum sexangulare* (Bulnh.) Lund., × 366.
10. *Staurastrum sexangulare* (Bulnh.) Lund. var. *asperum* Playf., × 366.
11. *Staurastrum Tohopekalegense* Wolle var. *trifurcatum* W. et G. S. West, forma, × 593.
12. *Staurastrum Tohopekalegense* Wolle var. *quadridentatum*, var. nov., × 593.

Figure 7

1. *Euastrum plesiocoralloides* W. et G. S. West var. *sinense*, var. nov., × 593.
2. *Euastrum capense* Fritsch var. *orientale*, var. nov., × 593.
3. *Euastrum strictum* (Boerg.), nob., × 593.
4. *Euastrum dubium* Naeg. var. *kwangsiense*, var. nov., × 593.
5. *Euastrum subinsulare*, sp. nov., × 593.
6. *Euastrum Gayanum* De Toni forma Groenb., × 593.
7. *Euastrum denticulatum* (Kirchn.) Gay, forma, × 593.
8. *Euastrum subporrectum*, sp. nov., × 366.
9. *Euastrum spinulosum* Delp. subsp. *africanum* Nordst. forma Borge, × 366.
10. *Euastrum spinulosum* Delp. subsp. *africanum* Nordst., forma, × 366.
11. *Euastrum spinulosum* Delp. subsp. *inermius* Nordst., × 593.
12. *Euastrum quadratum* Nordst. var. *javanicum* Nordst., forma, × 593.
13. *Euastrum fissum* W. et G. S. West var. *kwangsiense*, var. nov., × 593.
14. *Euastrum subpictum*, sp. nov., × 593.
15. *Euastrum subhypochondrum* Fritsch et Rich var. *spicatoides*, var. nov., × 593.
16. *Euastrum divergens* Jash., × 593.

17, 18. *Micrasterias decemdentata* Arch. forma Borge, × 366.

Figure 8

1. *Micrasterias Moebii* W. et G. S. West var. *javanica* Gutw., × 366.

2, 3. *Micrasterias Mahabuleshwarensis* Hobson, × 366.

4. *Micrasterias radiata* Hass., forma, × 240.
5. *Micrasterias apiculata* (Ehr.) Menegh., × 240.

6, 7. *Micrasterias Thomasiana* Arch., × 210.

8. *Micrasterias alta* Wolle, forma, × 240.

Figure 1

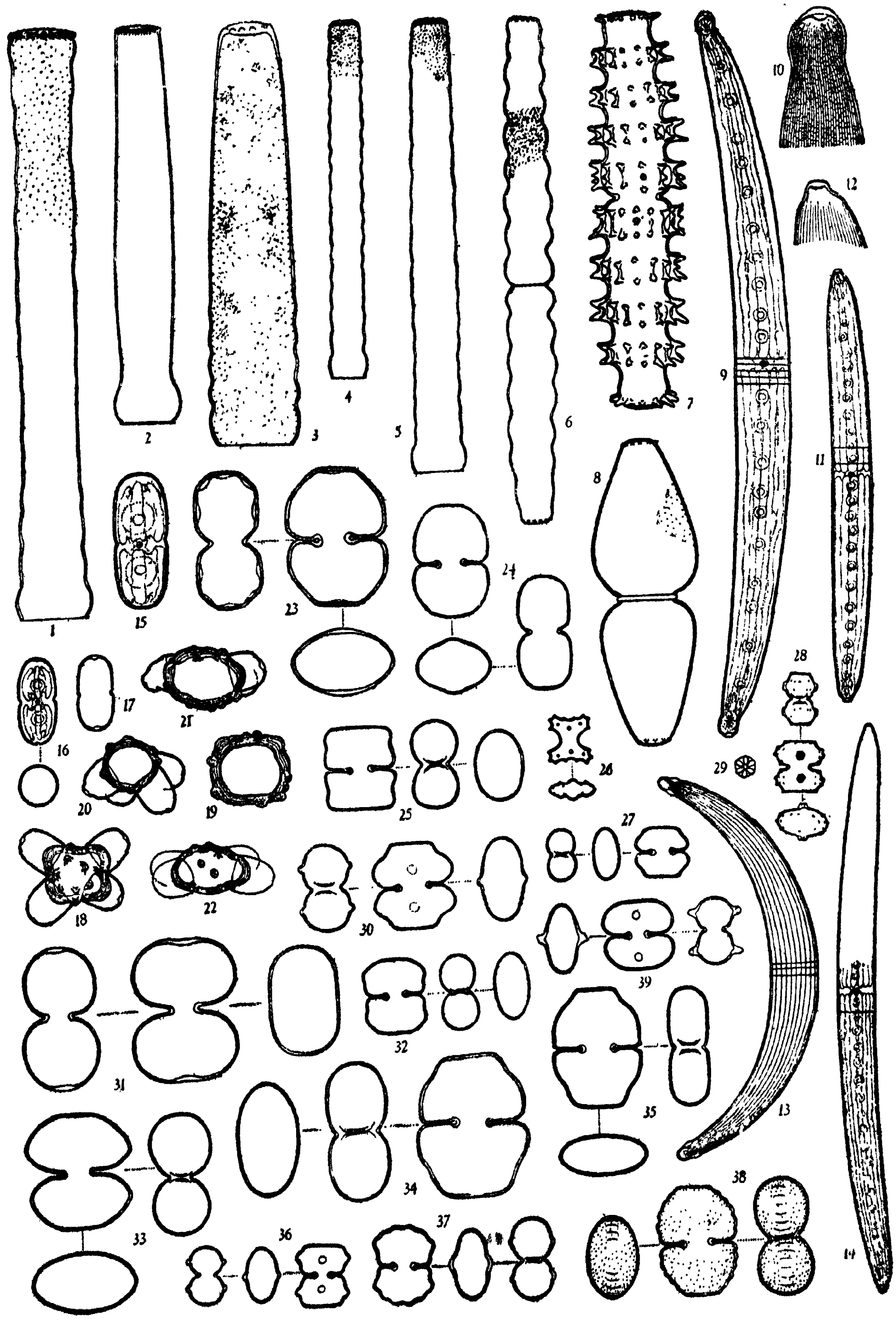
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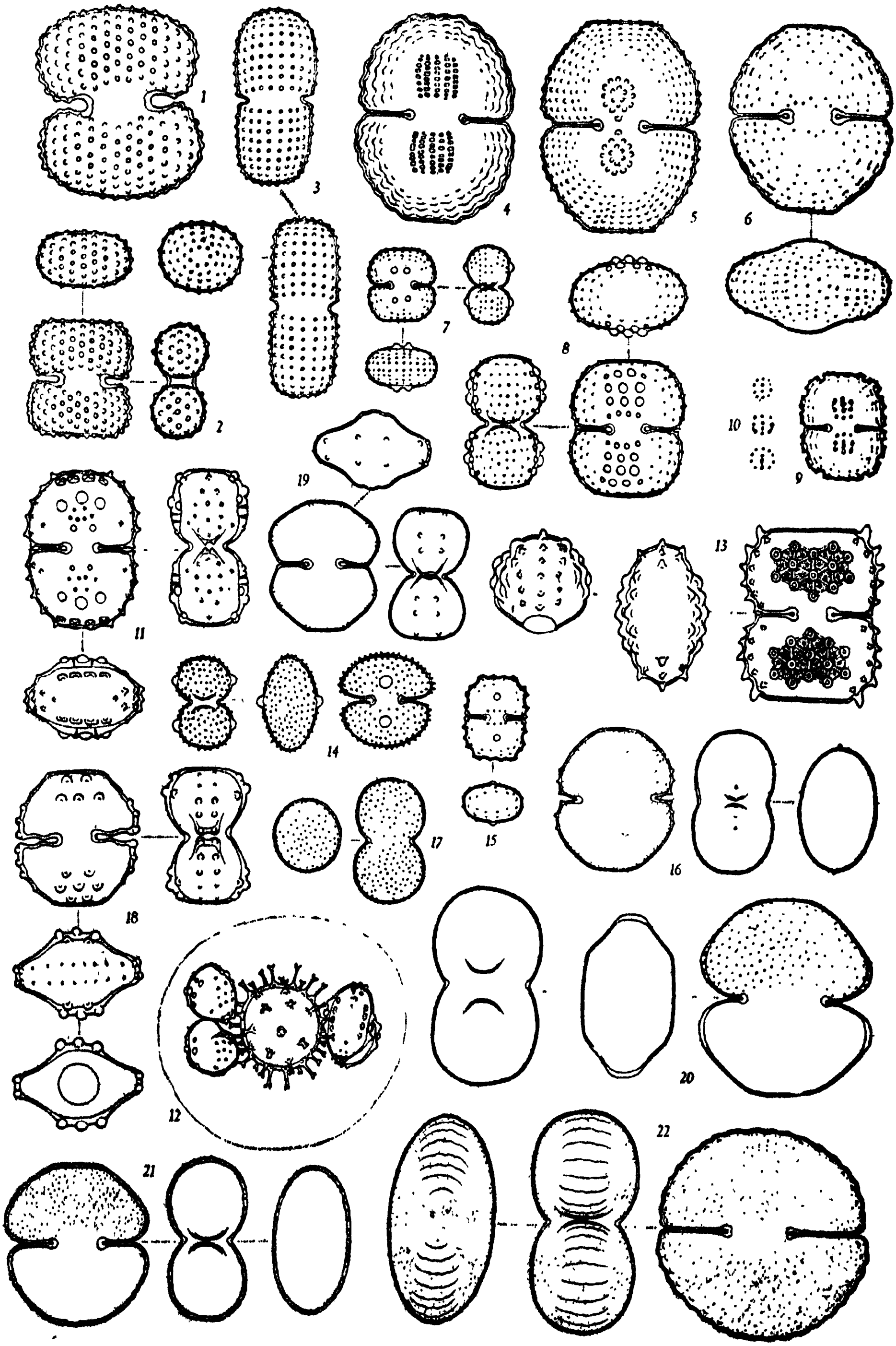
Figure 2



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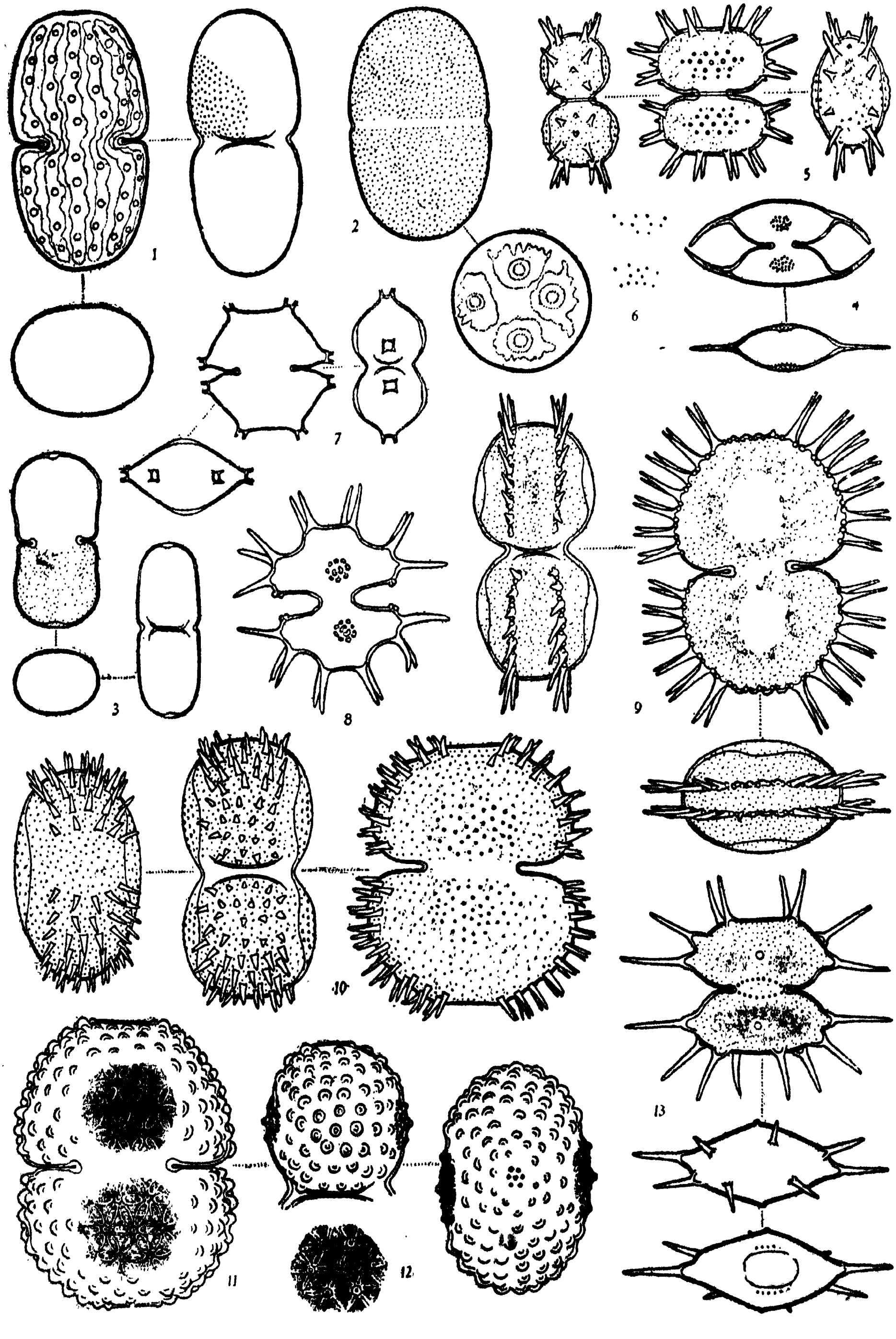


Figure 4

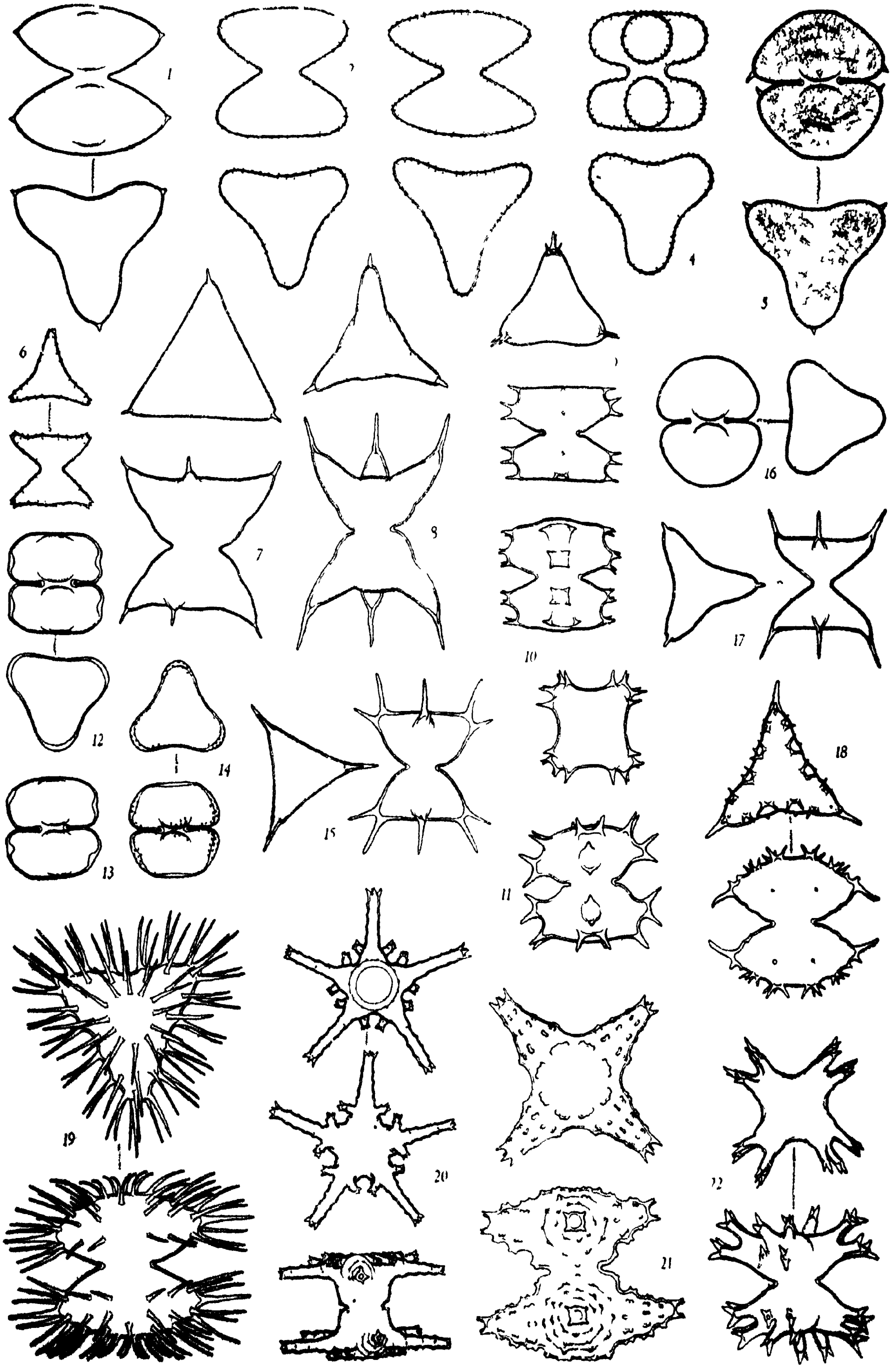


Figure 5

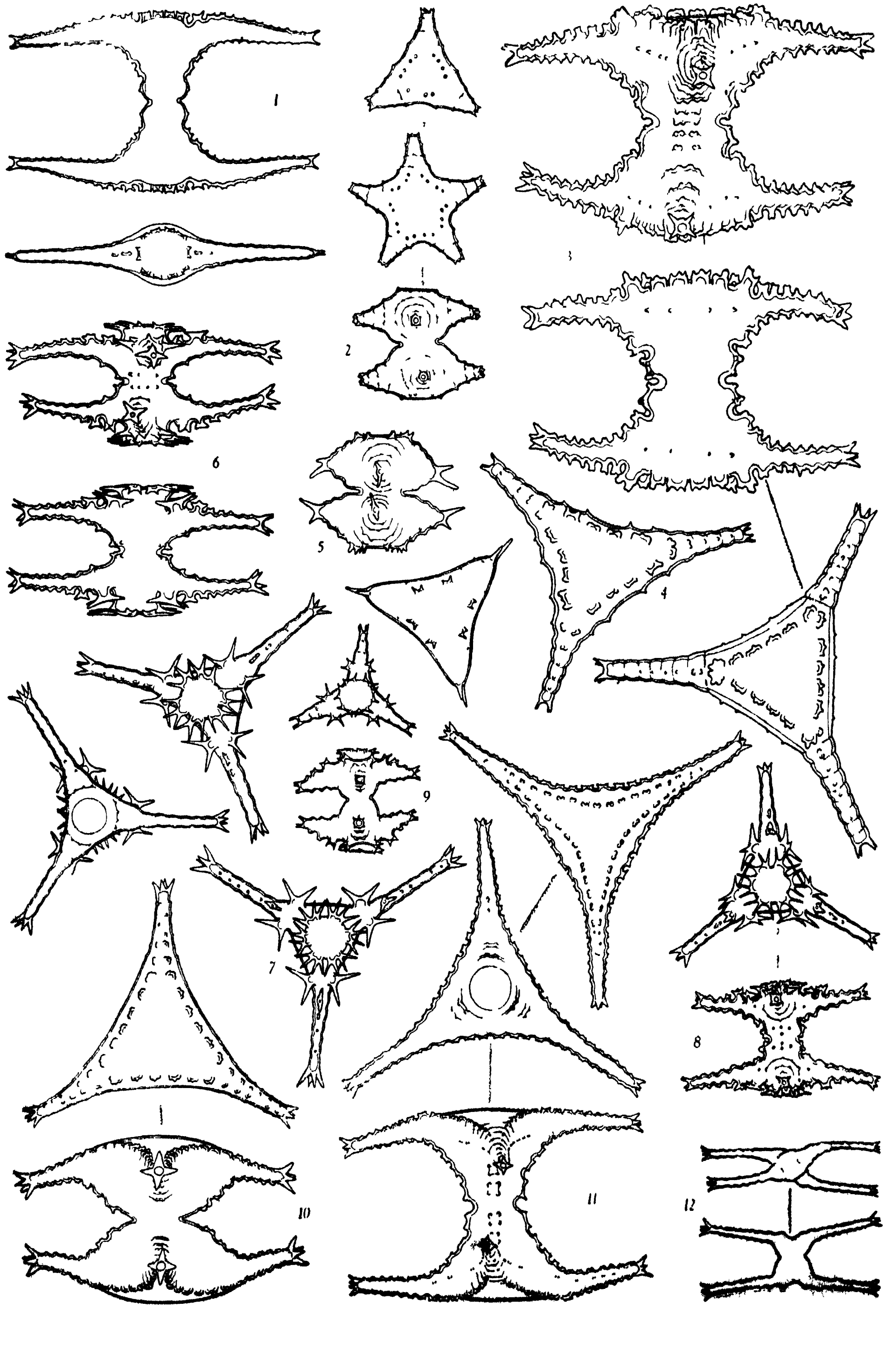


Figure 6

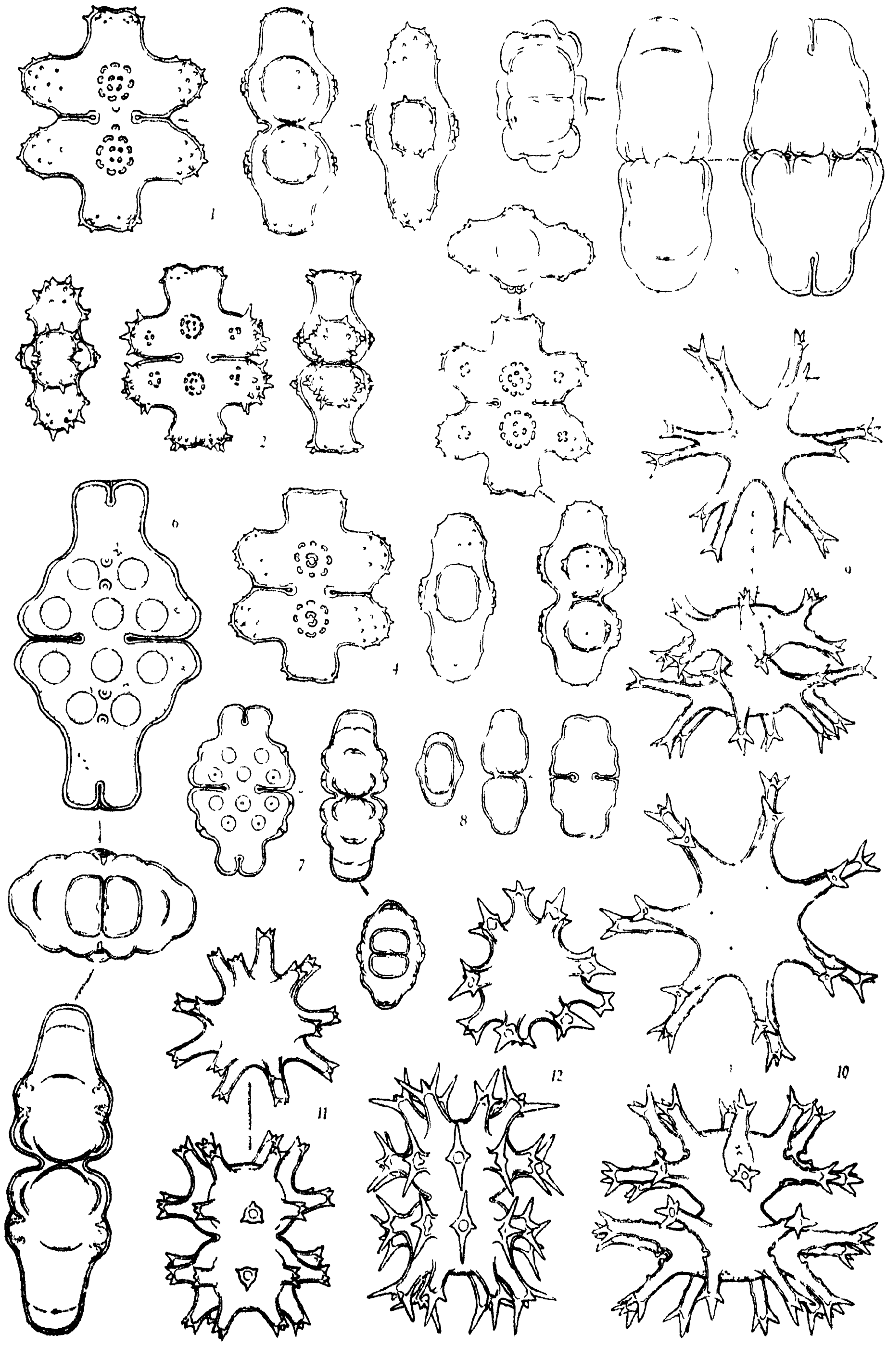


Figure 7

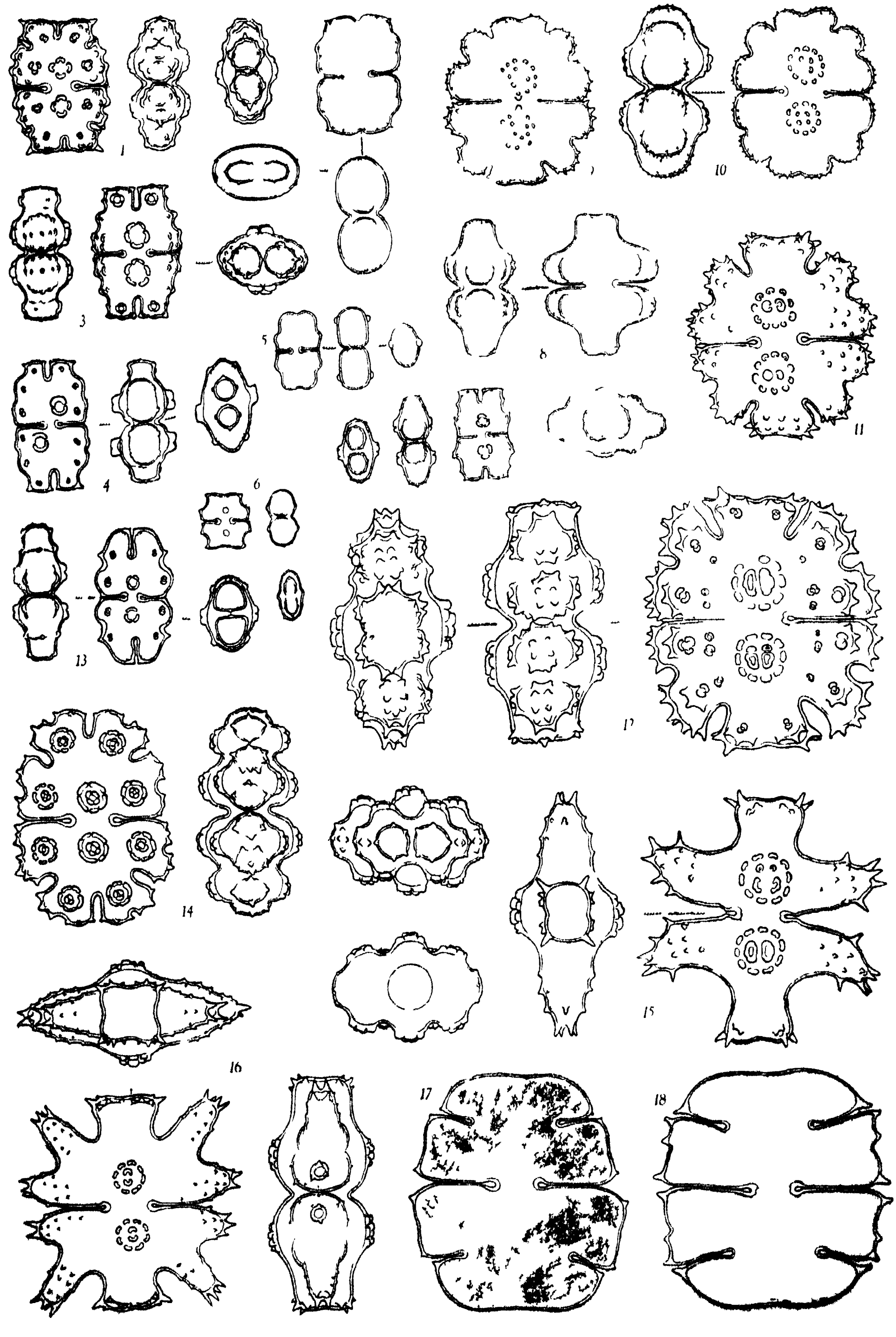
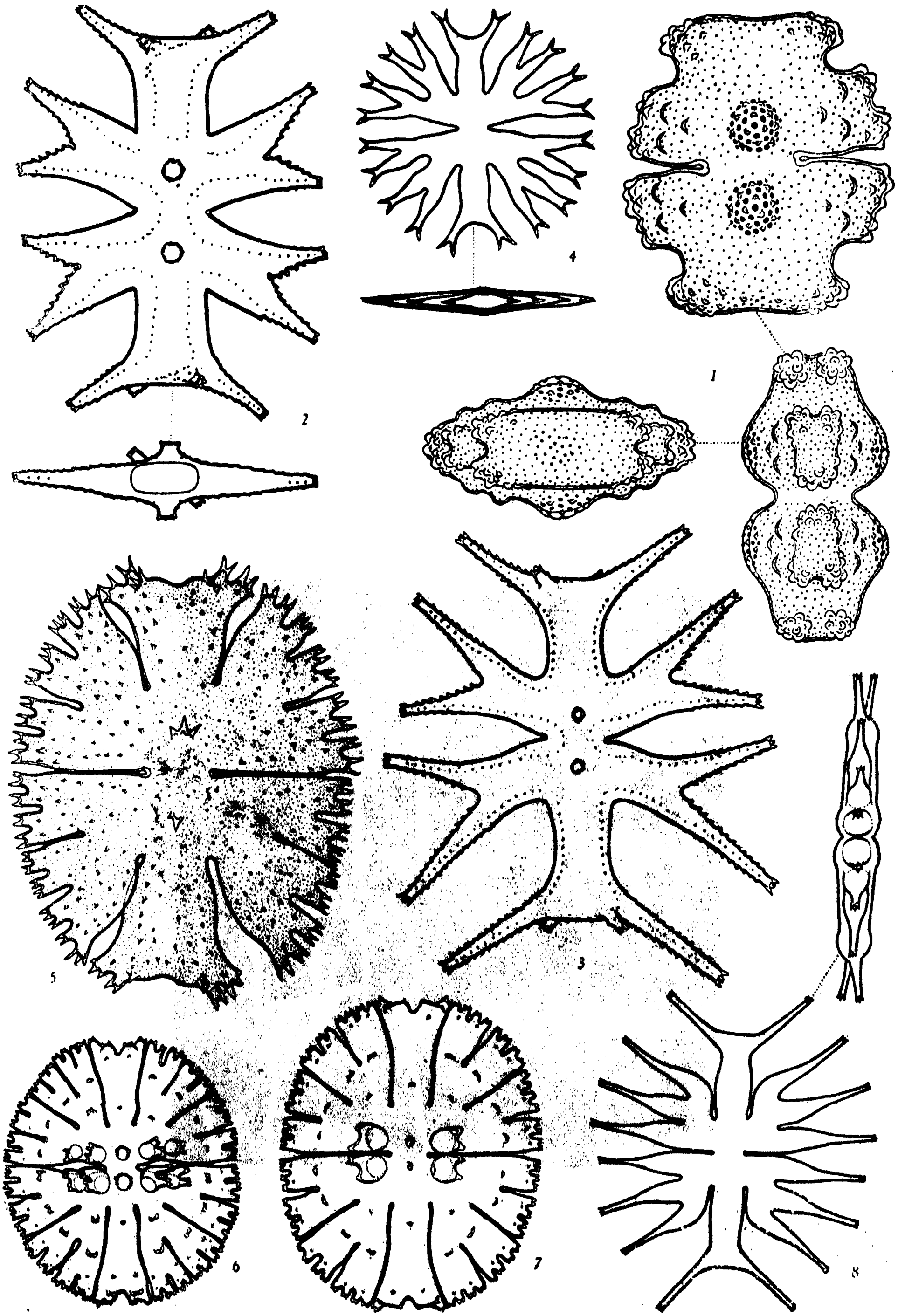


Figure 8



A PECULIAR EFFECT OF AUXIN (A PRELIMINARY NOTE)

Y. W. TANG

It is now known that the application of auxin to a plant tissue may result a wide variety of responses, such as promotion of root formation, inhibition of root growth, parthenocarpy, bud inhibition, cambial activity, delay of abscission, etc. In the preliminary experiments with seedling of kidney bean, an additional interesting phenomenon which will be described in the following few lines was observed. When synthetic indoleacetic acid in lanolin was smeared on the cutting surface of the stem, a curvature, opposite to the leaf, immediately below was obtained under the point of application. Whereas pure lanolin was used, no curvature was obtained. The magnitude of the curvature were increased with the increasing of the concentration of indoleacetic acid in lanolin (Fig. 1). The stem of broad bean gave the same response to auxin as the kidney beans. It was also found that indolebutyric acid, α-naphthaleneacetic acid, α-naphthoxyacetic acid, phenoxyacetic acid, 2,4-dichlorophenoxyacetic acid could duplicate the results obtained by using indoleacetic acid. However, they produced no curvature at all after application of tryptophane which was claimed to be the precursor of indoleacetic acid. As far as available data are concerned it is very difficult to explain such kind of growth phenomenon. The mechanism of the curvature, therefore, remains to be solved.

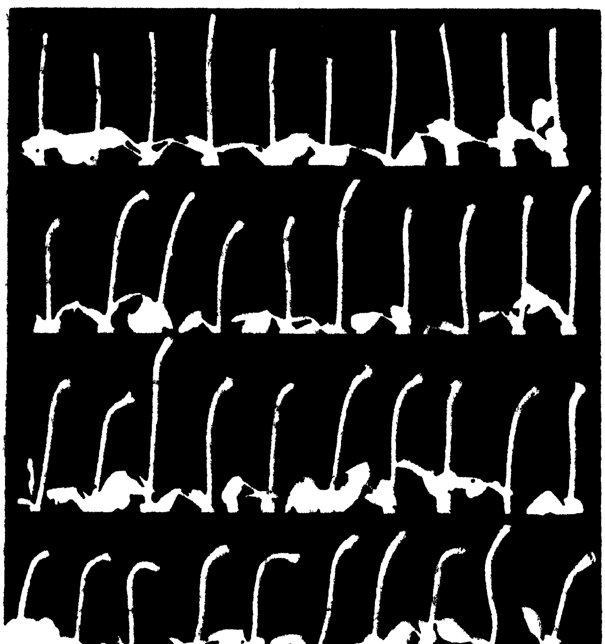


Fig. 1. Concentration effect of indoleacetic acid upon the production of stem curvature of kidney bean. From the top to bottom: pure lanolin, 0.5%, 1%, and 2% of indoleacetic acid-lanolin mixture 22 hrs. after treatment.

A STUDY ON THE OEDOGONIACEAE OF KWANGTUNG, SOUTH CHINA

SHANG-HAO LEY

Our knowledge of the Oedogoniaceae of the Kwangtung province, south China, up to the present is very scanty. Apart from one species, *Oedogonium Pringsheimmi* Cr. et Wittr., has previously been recorded from the Honan Island, Canton, by Dr. L. C. Li in 1935 (Lingnan Sci. Journ. 14: 461. 1935), nothing more is known from this province. This present investigation which deals specially with this group of algae is represented in the writer's collections assembled in the vicinity of Pingshek and Canton by himself in 1942 and 1947. Besides these collections, a few samples were collected by his friends, Mr. T. H. Ho of this Institute, Mr. K. F. Lee of the Department of Biology of the Sun Yatsen University, and Mr. H. T. Chang of the Botanical Institute of the same University. The total number of the species and varieties obtained is thirty eight, six of them, viz., *Oedogonium cantonense, Oedogonium exile, Oedogonium subplagiostomum, Oedogonium kwangtungense, Oedogonium speciosum,* and *Bulbochaete macrandria,* are described as new species.

Bulbochaete macrandria is a dioecious-macrandrous species. As far as we know that the dioecious-macrandrous members are common in the genus *Oedogonium,* and no such a representative has previously been found in the genus *Bulbochaete.* Thus the discovery of this species is of particular interest to the understanding of this genus and the family, Oedogoniaceae.

Another interesting point in this study is that the species collected in Pingshek, northern Kwangtung, is quite different from those found in Canton, southern Kwangtung. In the writer's samples, only a few members, viz., *Oedogonium Pringsheimii, Bulbochaete intermedia* and *Bulbochaete rectangulare,* are found in the north and south. The difference may be related to some ecological factors and the collecting seasons. The writer hopes that facts underlying in this peculiar phenomenon will be elucidated in the near future.

All the data used in this paper are taken from the writer's material.

The writer wishes to express his thanks to Dr. C. C. Jao for his constant help and criticisms in the preparation of this paper, and to Messrs. T. H. Ho, K. F. Lee, and H. T. Chang for their generous cooperation in collecting specimens for him.

OEDOGONIUM Link

MONOECIOUS SPECIES

OEDOGONIUM AUTUMNALE Wittr., Nov. Act. Soc. Sci. Upsal., ser. 3, 9: 11. 1874.

Cell. veget.	14—22 μ diam., 34—60 μ long.
Oogon.	43—51 μ diam., 42—50 μ long.
Oospor.	39—47 μ diam., 39—47 μ long.
Cell. antherid.	11—17 μ diam., 5—11 μ long.

Scattered among *Vaucheria sessiles* f. *repens* in a ditch of running water, Tangkau, Pingshek, Feb. 16, 1942, *Ley 37;* mixed with other *Oedogonia* and *Spirogyrae* in a pond, Pingshek, March 20, 1942, *Ley 36; scattered* among *Vaucheriopsis sinensis* Ley in a pond, Feekangchai, Pingshek, March 22, 1942, *Ley 42.*

OEDOGONIUM CRISPUM (Hass.) Wittr. f. INFRATUM Hirn, Act. Soc. Sci. Fenn. 27: 161. 1900.

Cell. veget.	16—18 μ diam.,	39—54 μ long.
Oogon.	43—50 μ diam.,	46—50 μ long.
Oospor.	36—42 μ diam.,	39—46 μ long.
Cell. antherid.	8—10 μ diam.,	5—10 μ long.

Scattered among *Vaucheria sessiles* f. *repens* in a ditch of running water, Tangkau, Pingshek, Feb. 16, 1942, *Ley 27;* mixed with other *Oedogonia* and *Spirogyrae* in a pond, Pingshek, March 20, 1942, *Ley 36.*

OEDOGONIUM GLOBOSUM Nordst., Minneskr. Fys. Saellsk. Lund 7: 20, pl. 2, fig. 16. 1878.

Cell. veget.	13—18 μ diam.,	52—91 μ long.
Oogon.	28—39 μ diam.,	33—47 μ long.
Oospor.	26—31 μ diam.,	29—35 μ long.
Cell. antherid.	10—13 μ diam.,	4— 7 μ long.

In stagnant water, Hwangpu, Canton, May 15, 1947, *Ley 552,* very common; in a rice field, Hwanghwa Kang, Canton, May 18, 1947, *Ley 608,* scattered.

OEDOGONIUM GLOBOSUM Nordst. f. NANYOHENSE Jao, Sinensia 9: 263, pl. 1, fig. 1, 2. 1938.

Cell. veget.	10—15(-17) μ diam.,	52—75 μ long.
Cell. suff.	14—18 μ diam.,	57—78 μ long.
Oogon.	37—41 μ diam.,	39—46 μ long.
Oospor.	37—36 μ diam.,	33—36 μ long.
Cell. antherid.	10—13 μ diam.,	4— 7 μ long.

In stagnant water, Hwangpu, Canton, May 15, 1947, *Ley 551.*

OEDOGONIUM NODULOSUM Wittr., Bih. Sv. Vet.-Akad. Handl. 1: 22, pl. 1, figs. 8-10. 1872.

Cell. veget.	23—26 μ diam.,	40—70 μ long.
Oogon.	46—52 μ diam.,	44—50 μ long.
Oospor.	42—44 μ diam.,	42—46 μ long.
Cell. antherid.	19—20 μ diam.,	4— 7 μ long.

Mixed with other filamentous algae in a pond, West Villege, Canton, May 27, 1947, *Ley 658.*

OEDOGONIUM OBESUM (Wittr.) Hirn, Act. Soc. Sci. Fenn. 27: 166, pl. 26, fig. 148. 1900.

Cell. veget.	14—18 μ diam.,	54—76 μ long.
Oogon.	41—46 μ diam.,	40—51 μ long.
Oospor.	34—39 μ diam.,	33—39 μ long.
Cell. antherid.	14—17 μ diam.,	5— 6 μ long.

Scattered among *Vaucheria sessiles* f. *repens* in a ditch of running water, Tangkau, Pingshek, Feb. 16, 1942, *Ley 27;* mixed with other *Oedogonia* and *Spirogyrae* in a pond, Pingshek, March 20, 1942, *Ley 36.*

Oedogonium oblongum Wittr., Bot. Notiser 1872: 2. 1872.

Cell. veget.	5— 7 μ diam.,	43—76 μ long.
Oogon.	22—25 μ diam.,	25—33 μ long.
Oospor.	19—22 μ diam.,	25—33 μ long.
Cell. antherid.	6— 7 μ diam.,	7— 8 μ long.

Mixed with other *Oedogonia* and *Spirogyrae* in a pond, Pingshek, March 20, 1942. *Ley 36.*

Oedogonium pithophorae Wittr., Bot. Notiser 1878: 141. 1878.

Cell. veget.	8—11 μ diam.,	26—47 μ long.
Oogon.	27—31 μ diam.,	31—33 μ long.
Oospor.	23—26 μ diam.,	24—26 μ long.
Cell. antherid.	8— 9 μ diam.,	4— 7 μ long.

Mixed with other filamentous algae in a slowly running stream beside a hill, Hwangpu, Canton, May 15, 1947, *Ley 546,* scattered.

In general appearance, this plant should also be compared with *Oedogonium crispum* (Hass.) Wittr. var. *gracillescens* Wittr., but it is distinguished from the latter by its smaller dimensions and the pyriform-globose oogonium.

Oedogonium Vaucherii (Le Cl.) A. Br. et Wittr., Oefv. Vet.-Akad. 27: 121. 1870.

Cell. veget.	20—26 μ diam.,	52—94 μ long.
Oogon.	44—47 μ diam.,	39—48 μ long.
Oospor.	36—44 μ diam.,	33—44 μ long.
Cell. antherid.	18—21 μ diam.,	3— 8 μ long.

Mixed with other filamentous algae in a rice field, Hwangpu, Canton, May 15, 1947, *Ley 551,* common.

DIOECIOUS-MACRANDROUS SPECIES

Oedogonium cantonense, sp. nov. (Fig. 1, *a, b*)

Oe. dioicum, macrandrium (?); cellulis vegetativis capitellatis, superioribus semper subcuneatis et brevioribus quam inferioribus; cellulis basalibus hemisphaericis; oogoniis signulis vel 3-continuis, globosis vel subglobosis, operculo apertis, circumscissione mediana; oosporis depresso-globosis, oogonia fere complentibus; membrana sporae laevi.

Cell. veget. sup.	18—23 μ diam.,	20—28 μ long.
Cell. veget. inf.	13—16 μ diam.,	40—60 μ long.
Cell. basal.	38 μ diam.,	13 μ long.
Oogon.	50—56 μ diam.,	42—50 μ long.
Oospor.	46—50 μ diam.,	40—54 μ long.

Mixed with other filamentous algae in a pond, West Villege, Canton, May 27, 1947, *Ley 658,* rare.

This Chinese plant is characterized by the particular shape of its vegetative cells, the median division of the oogonium and the hemispherical basal cell.

OEDOGONIUM CRASSUM (Hass.) Wittr., Bih. Sv. Vet.-Akad. Handl. 1: 20. 1972.

Cell. veget. plant. masc.	28—31 μ diam.,	117—156 μ long.
Cell. veget. plant. fem.	28—41 μ diam.,	150—200 μ long.
Oogon.	67—75 μ diam.,	72—111 μ long.
Oospor.	65—73 μ diam.,	65— 83 μ long.
Cell. antherid.	23—30 μ diam.,	8— 13 μ long.

In a ditch, Shekpei Villege, Canton, May 23, 1947, *Ley 648,* common; in a pond, West Villege, Canton, May 27, 1947, *Ley 658,* scattered.

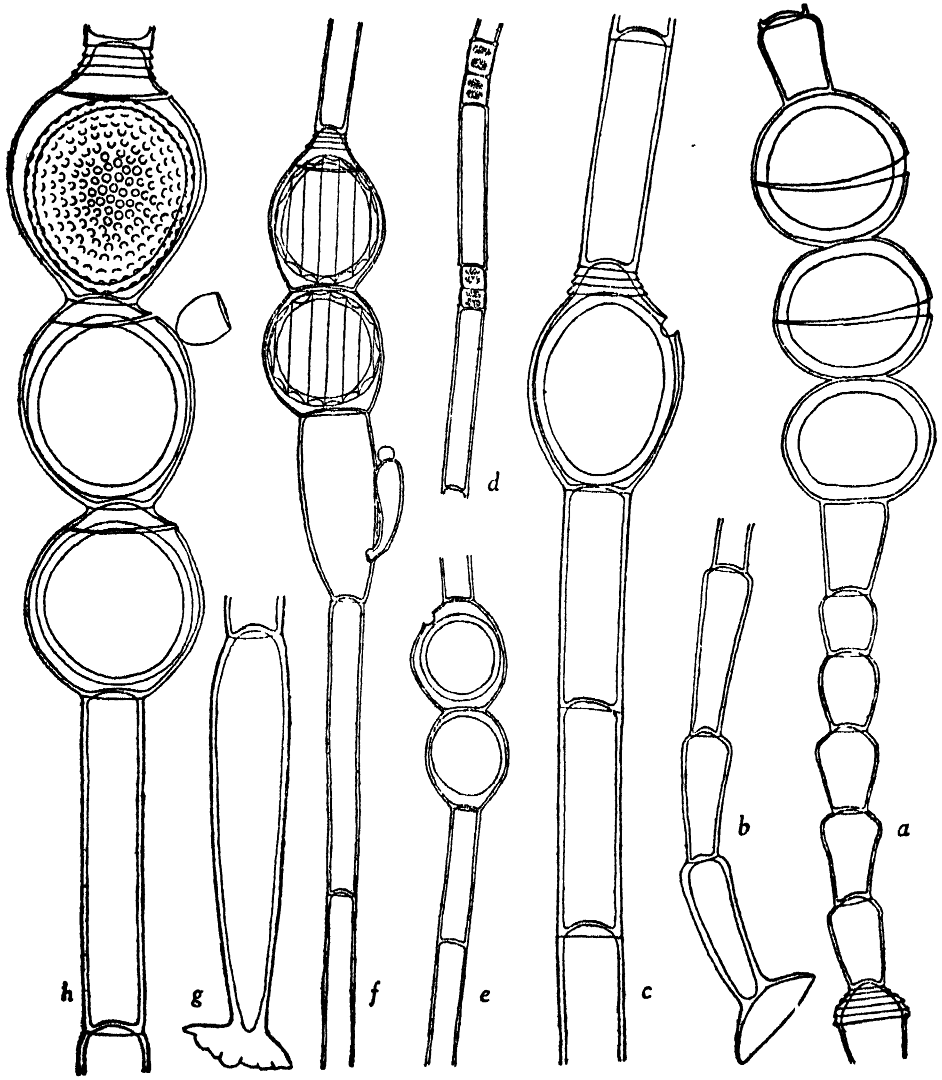


Fig. 1. *a-b. Oedogonium cantonense* Ley, sp. nov. *c. Oedogonium exile* Ley, sp. nov. *d-e. Oedogonium subplagiostomum* Ley, sp. nov. *f. Oedogonium kwangtungense* Ley, sp. nov. *g-h Oedogonium speciosum* Ley, sp. nov. All figures × 370, but *d* × 550.

OEDOGONIUM EXILE, sp. nov. (Fig. 1, *c*)

Oe. dioicum, macrandrium (?); cellulis vegetativis cylindricis; oogoniis singulis, oblongo-oviformibus vel oboviformibus, poro superiore apertis; oosporis oblongo-oviformibus, oogonia fere complentibus, raro non complentibus; membrana laevi.

Cell. veget.	8—14 μ diam.,	50—65 μ long.
Oogon.	36—39 μ diam.,	48—50 μ long.
Oospor.	35—38 μ diam.,	41—44 μ long.

Epiphytic on decayed leaves in a rice field, West Villege, Canton, May 27, 1947, *Ley 650,* rare.

No male plant of this species has been found in the writer's material. Judging from its characteristics stated above, especially its comparatively small vegetative cells, it seems better to determine it as a new species.

OEDOGONIUM HOWARDII G. S. West, Jour. Bot. 42: 281, pl. 464, figs. 1-5. 1904; Tiffany, Brittonia 2: 196, pl. 1, figs. 11, 12. 1936.

Cell. veget. plant. masc.	6— 8 μ diam.,	15—26 μ long.
Cell. veget. plant. fem.	8—10 μ diam.,	18—23 μ long.
Oogon.	20—23 μ diam.,	18—23 μ long.
Oospor.	18—22 μ diam.,	17—18 μ long.
Cell. antherid.	5— 7 μ diam.,	3— 6 μ long.

In a ditch, Shekpei Villege, Canton, May 23, 1947, *Ley 645,* scattered.

This species has previously been reported from the West Indies and North America. The Chinese plant differs slightly from the typical form in having comparatively smaller cell dimensions and always thickened cell wall. As the typical form of this species is varying in size (*cf.* Tiffany, *loc. cit.*), it seems better to refer the smaller plant to this species also.

OEDOGONIUM HUNANENSE Jao, Sinensia 9: 265, pl. 1, figs. 9-12. 1938.

Forma oogoniis oosporisque plerumque obovoideis, diametro angustioribus quam in forma speciei typica.

Cell. veget.	5— 7 μ diam.,	15—18 μ long.
Oogon.	15—17 μ diam.,	18—21 μ long.
Oospor.	13—14 μ diam.,	14—17 μ long.
Cell. antherid.	5— 7 μ diam.,	3— 5 μ long.

Epiphytic on decayed leaves and on other filamentous algae in a pond, West Villege, Canton, May 27, 1947, *Ley 658,* very common.

OEDOGONIUM LAGENIFORME Hirn, Act. Soc. Sci. Fenn. 27: 291, pl. 13, fig. 68. 1900; Tiffany, Brittonia 2: 168, pl. 1, figs. 16, 17. 1936.

Cell. veget.	10—12 μ diam.,	52—83 μ long.
Oogon.	34—40 μ diam.,	52—68 μ long.
Oospor.	28—35 μ diam.,	34—40 μ long.

Mixed with other filamentous algae in a slowly running stream beside a hill, Hwangpu, Canton, May 15, 1947, *Ley 546,* scattered.

This species has previously been recorded in Brazil, North America, and Chungking, China. In the specimens from Brazil and Chungking, only female plants were

found. Tiffany has found the male plants from the specimens collected in Puerto Rico by N. Wille. In the present collection, no male plant has been found also. The female plants bear the characterized inferiorly inflated oogonia similar to those shown in Hirn's drawing (*loc. cit.*).

OEDOGONIUM MAMMIFERUM Wittr., Nov. Act. Soc. Sci. Upsal. ser. 3, 9: 16. 1874; Nordst., Oefv. K. Vet.-Akad. Forh. 34: 25, pl. 3, figs. 3-6. 1877.

Cell. veget.	4—6 μ diam.,	26—34 μ long.
Oogon	23—25 μ diam.,	21—23 μ long.
Oospor.	11—23 μ diam.,	11—13 μ long.

In stagnant water, Hwangpu, Canton, May 15, 1947, *Ley 553*, very abundant.

This is a first record of this species in China, although it is one of those world-wide-distributed species.

OEDOGONIUM ORIENTALE Jao, Papers Mich. Acd. Sci. Arts and Lett. 19: 85, pl. 5, figs. 4-7. 1934.

Cell. veget. plant. masc.	13—15 μ diam.,	57—96 μ long.
Cell. veget. plant. fem.	13—16 μ diam.,	78—117 μ long.
Cell. suff.	13—21 μ diam.,	83—88 μ long.
Cell. basal.	15—20 μ diam.,	98—112 μ long.
Oogon.	33—41 μ diam.,	57—85 μ long.

In a ditch, Shekpei, Canton, May 23, 1947, *Ley 645*, scattered.

The specimens examined here differ from the typical form of this species in the terminal cell never becoming a long hyaline seta. It should be compared with *Oe. crenulatocostatum* Wittr., from which it differs in the longitudinal ribs of the mesospore being not crenulated.

OEDOGONIUM PRINGSHEIMII Cr., Hedwigia 2: 17, pl. 1, figs. C 1-4. 1859; Wittr., Nov. Act. Soc. Sci. Upsal., Ser. 3, 9: 33, pl. 1, figs. 16, 17. 1874.

Cell. veget.	16—18 μ diam.,	29—56 μ long.
Oogon.	36—40 μ diam.,	35—36 μ long.
Oospor.	30—31 μ diam.,	31—32 μ long.
Cell. antherid.	14—15 μ diam.,	6—8 μ long.

In a pond, Feekangchai, Pingshek, March 20, 1942, *Ley 36*; in a small pond on a hill, Honan, Canton, July 2, 1947, *Ley 223*, collected by Mr. T. H. Ho; in a pond, West Villege, Canton, May 27, 1947, *Ley 658*, common.

OEDOGONIUM PRINGSHEIMII Cr. var. NORDSTEDTII Wittr., Wittrock and Nordstedt, Alg. Exsicc. 8. 1877.

Cell. veget.	9—13 μ diam.,	21—34 μ long.
Oogon.	32—36 μ diam.,	32—42 μ long.
Oospor.	23—25 μ diam.,	23—25 μ long.
Cell. antherid.	9 μ diam.,	7—9 μ long.

In a ditch, Tongkau, Pingshek, Feb. 16, 1942, *Ley 27*, rather common.

OEDOGONIUM SUBAREOLATUM Tiffany, Brittonia 2: 168, pl. 1, figs. 13-15. 1936. (Not *Oedogonium subareolatum* Jao, Sinensia 9: 267, pl. 2, figs. 16-18. 1938).

Oedogonium pseudaureum Jao, Bot. Bull. Acad. Sinica 1: 90, fig. 1, *f, g*. 1947.

Cell. veget.	8—12 μ diam.,	39—44 μ long.
Oogon.	31—36 μ diam.,	39—44 μ long.
Oospor.	27—30 μ diam.,	34—36 μ long.
Cell. antherid.	8— 9 μ diam.,	(3–) 5—10 μ long.

In stagnant water, Hwangpu, Canton, May 15, 1947, *Ley 552*, scattered; in slowly running stream beside a hill, Hwangpu, Canton, May 15, 1947, *Ley 546*, scattered.

OEDOGONIUM SUBPLAGIOSTOMUM, sp. nov. (Fig. 1, *d, e*)

Oe. dioicum, macrandrium; oogoniis 2-continuis vel singulis, oboviformi-globosis, poro superiore apertis; oosporis globosis; oogonia non complentibus; membrana laevi crassaque; antheridiis 2-cellularibus; plerumque cum cellulis vegetativis alternis; spermatibus divisione horizontali binis.

Cell. veget. plant. masc.	8— 9 μ diam.,	33—73 μ long.
Cell. veget. plant. fem.	10—15 μ diam.,	36—55 μ long.
Oogon.	31—37 μ diam.,	34—44 μ long.
Oospor.	27—30 μ diam.,	28—30 μ long.
Cell. antherid.	8— 9 μ diam.,	7— 9 μ long.

In stagnant water, Hwangpu, Canton, May 15, 1947, *Ley 552*, scattered.

This species is nearest to *Oedogonium plagiostomum* var. *gracilius* Wittr., but is distinctively separated from the latter by its smaller dimensions in all of the cells, especially those of the vegetative cells.

DIOECIOUS-NANNANDROUS SPECIES

OEDOGONIUM CILIATUM (Hass.) Pringsh., Ber. Akad. Berlin 1856: 227, pl. 1, figs. 1-10. 1856.

Cell. veget.	16—19 μ diam.,	(28–) 46—68 μ long.
Oogon.	43—46 μ diam.,	57—64 μ long.
Oospor.	42—45 μ diam.,	50—57 μ long.
Androsp.	14 μ diam.,	9 μ long.
Stip. nannandr.	10—14 μ diam.,	21—28 μ long.
Cell. antherid.	7— 9 μ diam.,	(5–) 7—11 μ long.

In a pond, Feekangchai, Pingshek, March 20, 1942, *Ley 35, 36*, common.

This Chinese plant agrees fairly well in all respects with the typical form of this species, except that its mature oogonia are usually obovoid in form.

This is the first record of this species in China.

OEDOGONIUM KWANGTUNGENSE, sp. nov. (Fig. 1, *f*)

Oe. dioicum, nannandrium; cellulis vegetativis cylindricis; oogoniis singulis vel 2—4-continuis, subglobosis vel globoso-oviformibus, operculo apertis, circumscissione superiore; oosporis subglobosis vel globoso-oviformibus, oogonia complentibus vel fere complentibus, membrana triplici: mesosoporio longitudinaliter costato, costis in medio oosporae circa 12—14, episporio et endosporio laevi; cellulis suffultoriis tumidis; nannandribus paululum curvatis, in cellulis suffultoriis sedentibus, antheridiis exterioribus.

Cell. veget.	10—12 μ diam.,	80—125 μ long.
Cell. suff.	26—39 μ diam.,	52— 65 μ long.
Oogon.	38—42 μ diam.,	41— 54 μ long.
Oospor.	36—41 μ diam.,	37— 44 μ long.
Stip. nannandr.	7—11 μ diam.,	32— 44 μ long.
Cell. antherid.	5 μ diam.,	5 μ long.

In a ditch, Shekpei Villege, Canton, May 23, 1947, *Ley 645*, scattered; in stagnant water, Shekpei Villege, Canton, May 23, 1947, *Ley 647*, common.

This species is nearest to *Oe. Wolleanum* Wittr. and *Oe. michiganense* Tiffany. It is distinguished from the first by its smaller dimensions in all of the cells, the median longitudinally ribbed spore wall and the much swollened suffultory cells. It differs from the second in the smaller dimensions of the sexual cells, the longitudinal ribs of the median spore wall never crenulated, and the exterior antheridium.

OEDOGONIUM MACRANDIUM Wittr. var. PROPINGUUM (Wittr.) Hirn, Act. Soc. Sci. Fenn. 34: 42, pl. 4, fig. 20. 1906.

Cell. veget.	10—14 μ diam.,	28—50 μ long.
Oogon.	29—36 μ diam.,	29—41 μ long.
Oospor.	27—32 μ diam.,	25—29 μ long.
Stip. nannandr.	10—15 μ diam.,	19—21 μ long.
Cell. antherid.	7— 9 μ diam.,	4— 7 μ long.

In a pond, Feekangchai, Pingshek, March 20, 1942, *Ley 36, 37*, scattered.

OEDOGONIUM MACROSPERMUM W. et G. S. Wett, Jour. Roy. Micr. Soc. 1897: 472, pl. 7, figs. 6, 7. 1897.

Cell. veget.	10—13 μ diam.,	46—104 μ long.
Oogon.	35—46 μ diam.,	41— 48 μ long.
Oospor.	36—44 μ diam.,	36— 44 μ long.
Stip. nannandr.	8—10 μ diam.,	26— 30 μ long.
Cell. antherid.	6— 8 μ diam.,	13 μ long.

In a rice field, Hwanghwa Kang, Canton, May 18, 1947, *Ley 608*, scattered.

OEDOGONIUM SPECIOSUM, sp. nov. (Fig. 1, *g, h*)

Oe. dioicum, nannandrium; oogoniis oboviformi-subglobosis, 2—3-continuis; operculo apertis, circumscissione superiore; oosporis obovoideis vel subglobosis, oogonia non complentibus, membrana triplici: mesosporio scrobiculato, exosporio endosporioque laevi; nannandribus unicellularibus, in oogoniis sedentibus.

Cell. veget.	23—29 μ diam.,	101—140 μ long.
Oogon.	57—65 μ diam.,	70— 75 μ long.
Oospor.	52—54 μ diam.,	57— 64 μ long.
Cell. nannandr.	18—21 μ diam.,	19— 21 μ lcng.

In a pond, West Villege, Canton, May 27, 1947, *Ley 658*, common.

This species is easily distinguished from the other known *Oedogonia* by its oogonium in having a superior division, a scrobiculate median spore wall, and a unicellular dwarf male.

OEDOGONIUM PERSPICUUM Hirn, Act. Soc. Sci. Fenn. 27: 273, pl. 46, fig. 293. 1900.

Cell. veget. plant. masc.	28—36 μ diam.,	114—140 μ long.
Cell. veget. plant. fem.	33—41 μ diam.,	85—140 μ long.
Oogon.	78—83 μ diam.,	55— 91 μ long.
Oospor.	59—62 μ diam.,	62— 65 μ long.
Cell. nannandr.	18—23 μ diam.,	18— 20 μ long.

In stagnant water, Dingwoo Shan, Shiuhing, June 1946, *Ley 200,* collecting by Mr. H. T. Chang.

This alga has previously been recorded in Australia and Siam (?). The Chinese plant agrees fairly well in all respects with the typical form of this species, except that its oogonia are smaller in size.

The writer does not agree with Hirn and Tiffany in judging the Siamese alga *Oedogonium dioicum* Carter, listed in W. and G. S. West's paper (Bot. Tidssk. 24: 75, pl. 4, fig. 42. 1901) as a synonym of *Oe. perspicuum* Hirm (Hirn, Act. Soc. Sci. Fenn. 34: 45. 1906; Tiffany, Monograph, p. 141. 1930), since the former is a dioecious-macrandrous plant with the oogonium, as clearly showing in West's figure, divided superiorly, while the later is a dioecious-nannandrous plant with the oogonium divided medianly. Since the reproductive methods and the positions of division of the oogonium are the important specific characters, the writer agrees with West in referring the Siamese alga to *Oe. dioicum* Carter.

OEDOGONIUM SPIRALIDENS Jao, Papers Mich. Acad. Sci. Arts and Lett. 19: 84, pl. 5, figs. 1-3. 1934.

Cell. veget.	13—18 μ diam.,	80—117 μ long.
Cell. suff.	21 μ diam.,	75 μ long.
Oogon.	44—46 μ diam.,	59— 80 μ long.
Oospor.	36—41 μ diam.,	36— 45 μ long.

In stagnant water, Hwangpu, Canton, May 15, 1947, *Ley 552,* rare; in a ditch, Shekpei Villege, Canton, May 23, 1947, *Ley 645,* scattered; in stagnant water, Shekpei, Canton, May 23, 1947, *Ley 647,* scattered.

Neither male plants with antheridia nor dwarf males have been found in the specimens. According to Dr. C. C. Jao's opinion, that the dwarf males of this species are usually not easy to find, probably it is very easily dropped off.

The present plant should be compared with *Oe. pseudospirale* Nygaard (Trans. Roy. Soc. South Afr. 20: 136, fig. 32. 1932), an incompletely described species. As stated by Nygaard, "neither male threads, nor dwarf-males nor antheirdia were encountered. The species is probably dioecious-macrandrous." The writer supposes that *Oe. pseudospirale* and *Oe. spiraledens* may be of a single species, though even the dwarf-males of the former are unknown.

OEDOGONIUM UNDULATUM (Breb.) A. Br. *in* De Bary, Abh. Senck. Nat. Ges. 1: 94. 1854; Hirn, Act. Soc. Sci. Fenn. 27: 257, pl. 45, figs. 272-275. 1900.

Cell. veget.	15—18 μ diam.,	37—78 μ long.
Oogon.	45—50 μ diam.,	54—58 μ long.
Oospor.	42—48 μ diam.,	42—48 μ long.

Cell. androsp.	14—16 μ diam., 42—48 μ long.
Cell. nannandr.	7— 9 μ diam., 39—44 μ long.

In a small pond on a hill, Honan, Canton, July 2, 1947, *Ley 223,* collected by Mr. T. H. Ho, rare; in a rice field, Hwangpu, Canton, May 15, 1947, *Ley 551;* in stragnant water, Hwangpu, Canton, May 17, 1947, *Ley 552;* in a pond, Hwanghwa Kang, Canton, May 17, 1947, *Ley 603;* in a ditch, Shekpei Villege, Canton, May 23, 1947, *Ley 645, 647;* in a pond in the Campus of the Sun Yat-sen University, Canton, Aug. 1946, *Ley 199,* collected by Mr. K. F. Lee.

It is very commonly found in Canton, and also widely distributed in the other parts of China, but it is wanting in the specimens collected in Pingshek.

BULBOCHAETE Ag.

MONOECIOUS SPECIES

BULBOCHAETE MIRABILIS Wittr. f. IMMERSA (Wittr.) Hirn, Act. Soc. Sci. Fenn. 27: 352, pl. 58, fig. 367. 1900.

Cell. veget.	12—17 μ diam., 18—22 μ long.
Oogon.	25—32 μ diam., 40—43 μ long.
Oospor.	24—30 μ diam., 38—41 μ long.
Cell. antherid.	7—11 μ diam., 4— 6 μ long.

Epiphytic on *Vaucheria* in a pond, Pingshek, March 22, 1942, *Ley 43,* scattered.

BULBOCHAETE NANA Wittr., Bih. Sv. Vet.-Akad. Handl. 1: 7, pl. 1, fig. 9. 1872.

Cell. veget.	11—14 μ diam., 12—18 μ long.
Oogon.	20—24 μ diam., 32—38 μ long.
Oospor.	18—22 μ diam., 30—36 μ long.
Cell. antherid.	7— 8 μ diam., 5— 8 μ long.

Epiphytic on *Vaucheria* in a pond, Pingshek, March 22, 1942, *Ley 43.*

DIOECIOUS-MACRANDROUS SPECIES

BULBOCHAETE MACRANDRIA, sp. nov. (Fig. 2)

B. dioica, macrandria; cellulis vegetativis brevibus, longitudine latitudinem vix aequanti, lateribus convexis, cellulis itaque submoniliformibus vel subglobosis; oogoniis ellipsoideis, saepe oboviformi-ellipsoideis, patentibus vel erectis, sub setis terminalibus vel rarius sub cellulis vegetativis sitis, oogonia complentibus vel subtus non complentibus; membrana oosporae triplici: episporio laevi et tenui, mesosporio dense scrobiculato; antheridiis sub setis terminalibus sitis vel rarius patentibus, 1-3-cellularibus.

Cell. veget. plant. masc.	14—17 μ diam., 13—15 μ long.
Cell. veget. plant. fem.	13—18 μ diam., 13—15 μ long.
Cell. basal.	15—17 μ diam., 18—21 μ long.
Oogon.	23—25 μ diam., 34—38 μ long.
Oospor.	22—25 μ diam., 29—34 μ long.
Cell. antherid.	6— 8 μ diam., 5— 8 μ long.

Usually epiphytic on *Oedogonium undulatum* in a slowly flowing stream beside a rice field, Shekpei Villege, Canton, May 23, 1947, *Ley 645,* fairly common.

This species is distinguished from other species of the genus in the following characteristics. Firstly, it is a dioecious-macrandrous plant. Secondly, the spores is ellipsoid and densely scrobiculated. Thirdly, the suffultory cells are without division.

So far as we are aware, no dioecious-macrandrous plants have thitherto been found in the genus *Bulbochaete*. Formerly, algologists have supposed that the chief difference in the reproductive methods of these two genera *Bulbochaete* and *Oedogonium* lies in the fact that *Bulbochaete* has no dioecious-macrandrous species, therefore, the discovery of dioecious-macrandrous type in the genus *Bulbochaete* is certainly of great interest.

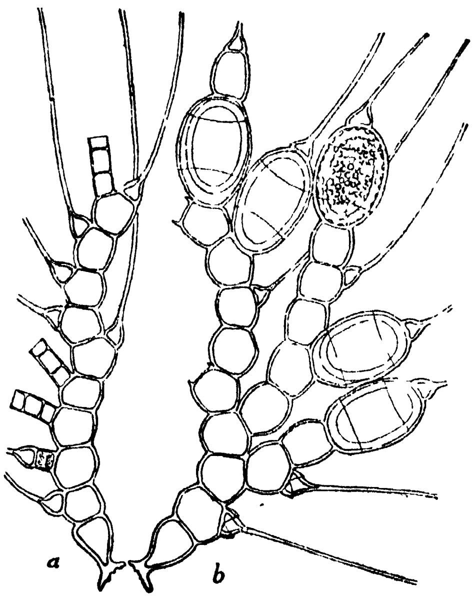


Fig. 2. *Bulbochaete macrandria* Ley, sp. nov. *a.* male plant, *b.* female plant. All figure × 370.

DIOECIOUS-NANNANDROUS SPECIES

BULBOCHAETE INTERMEDIA De Bary, Abh. Senck. Nat. Ges. 1: 72, pl. 4, figs. 1-7. 1854.

Cell. veget.	14—18 μ diam.,	36—59 μ long.
Oogon.	40—45 μ diam.,	29—36 μ long.
Oospor.	38—44 μ diam.,	27—34 μ long.
Cell. androsp.	11—12 μ diam.,	11—14 μ long.
Nannandr.	7—11 μ diam.,	22—27 μ long.

In a pond, Pingshek, March 10, 1942, *Ley 47: b,* scattered; in a pond, Shekpei Villege, Canton, May 23, 1947, *Ley 647,* rare.

BULBOCHAETE PYGMEAE Pringsh., Jahrb. Wiss. Bot. 1: 74. 1857.

Cell. veget.	12—15 μ diam.,	10—18 μ long.
Cell. basal.	16 μ diam.,	40 μ long.
Oogon.	22—25 μ diam.,	37—42 μ long.

Oospor.	20—25 μ diam.,	35—39 μ long.
Stip. nannandr.	9—11 μ diam.,	13—15 μ long.
Cell. antherid.	6— 8 μ diam.,	4— 6 μ long.

Epiphytic on decayed leaves and other filamentous algae in a pond in the campus of the Sun Yat-sen University, Shekpei, Canton, Aug. 1946, *Ley 198,* collected by Mr. K. F. Lee, scattered.

BULBOCHAETE RECTANGULARIS Wittr., Oefv. Sv. Vet.-Akad. Forh. 27: 142. 1870.

Cell. veget.	(12-) 18—21 μ diam.,	3— 7 μ long.
Oogon.	32—36 μ diam.,	14— 7 μ long.
Oospor.	30—34 μ diam.,	46—64 μ long.
Cell. androsp.	12—14 μ diam.,	48—63 μ long.
Stip. nannandr.	10—18 μ diam.,	16—18 μ long.
Cell. antherid.	7—11 μ diam.,	18—27 μ long.

In a pond, Pingshek, March 10, 1942, *Ley 47,* scattered; in a slowly flowing stream, beside the rice field, Shekpei Villege, Canton, May 23, 1947, *Ley 645,* scattered.

BULBOCHAETE REPANDA Wittr., Nov. Act. Soc. Sci. Upsal., ser. 3, 9: 55. 1874.

Cell. veget.	18—10 μ diam.,	18—34 μ long.
Oogon.	26—31 μ diam.,	44—49 μ long.
Oospor.	24—29 μ diam.,	42—47 μ long.
Cell androp.	13—14 μ diam.,	13—16 μ long.
Stip. nannandr.	13—18 μ diam.,	18—26 μ long.
Cell. antherid.	7— 9 μ diam.,	4— 6 μ long.

Epiphytic on the decayed-leaves and other filamentous algae in a pond, Hwanghwa Kang, Canton, May 17, 1947, *Ley 602,* scattered.

BULBOCHAETE SETIGERA (Roth.) C. A. Ag., Syn. Alg. 71. 1817.

Cell. veget.	18—25 μ diam.,	54—115 μ long.
Oogon.	68—77 μ diam.,	54— 58 μ long.
Oospor.	65—74 μ diam.,	53— 55 μ long.
Cell. androsp.	18 μ diam.,	6— 15 μ long.
Nannandr.	11—15 μ diam.,	28— 40 μ long.

In a pond, Pingshek, March 10, 1942, *Ley 47: a,* scattered.

STUDIES ON THE CRUCIFERAE OF CHINA, II.

TAI-YIEN CHEO

This paper reports on 13 genera including 23 species, 8 varieties, and 5 forms. All the species were known to China before, except *Iberis amara* Linn., an introduced species, is first reported. Most of the species are naturally distributed in the southwest and northwest provinces, and some of them have ornamental values and are cultivated in the flower-gardens. There are 2 monotypic genera, *Dipoma* and *Pegaeophyton*, they are confined in Western China from Yunnan to Sikang.

Analytical keys to genera and species are given together with descriptions. As for varieties and forms, only distinguishing characteristics are briefly stated. All specimens cited here are preserved in the herbarium of Academia Sinica and in the herbarium of University of Nanking, those from the latter are indicated by (HUN) as in the writer's first instalment on this subject.

1. Cotyledons accumbent or incumbent 2
1. Cotyledons conduplicate; silique oblong, with ensiform seedless beak; leaves lyrate-pinnaticleft .... *Eruca*.
2. Cotyledons accumbent 3
2. Cotyledons incumbent 8
3. Flowers yellow to orange-yellow; hoary herb with appressed bipartite hairs; silique linear, long, 4-sided or -angled .... *Cheiranthus*.
3. Flowers white, pinkish or purple 4
4. Fruit a silique 5
4. Fruit a silicle 6
5. Acaulescent herb, with thick long root; leaves rosulate, spathulate; flowers solitary on each scape; fruit broadly obovate .... *Pegaeophyton*.
5. Small herb, rootstock with clustered bulbils; leaves 2-3 above the middle of the stem, pinnate; flowers several, corymbose; fruit linear .... *Loxostemon*.
6. Valves indehiscent, winged; flowers racemed 7
6. Valves dehiscent, wingless, small, operculiform; flowers axillary; setulose herb........ *Dipoma*.
7. Petals equal; stamens 6 or more than 6; fruit didymous, compressed, 2-seeded—tall herb of umbelliferous habit .... *Megacarpaea*.
7. Petals unequal, outer 2 much larger; stamens 6; fruit orbicular or ovate, notched at the top... *Iberis*.
8. Flowers racemose 9
8. Flowers scapose, solitary, blue to rosy; stamens 6 or less than 6; silique ovate-oblong, leaf-like .... *Solms-Laubachia*.
9. Plant pubescent 10
9. Plant glabrous; flowers in wide panicled racemes; fruit indehiscent, coriaceous, with winged outgrowth .... *Pugionium*.
10. Erect branched hoary herbs, with appressed bipartite, forked or stellate hairs........ 11
10. Small decumbent or tufted herbs, with hairs not appressed 12
11. Flowers yellow; fruit more angular than *Cheiranthus;* seeds not winged .... *Erysimum*.
11. Flowers purple, rosy or white; fruit terete or compressed; seeds winged........ *Matthiola*.
12. Flowers scapigerous-racemed; valves smooth; tufted herb, glabrous or hoary pubescent...... *Braya*.
12. Flowers axillary; valves with few obtuse warty crests along margin and on the dorsal surface; small herb, strigose-pilose or with hoary flabby hairs .... *Hemilophia*.

ERUCA Adanson

Annual or biennial branching herbs, hispid or glabrescent; stem erect or ascendent, leafy, sometimes producing scape; leaves lyrate-pinnaticleft to bipinnaticleft; racemes ebracteate; flowers rather large; sepals oblong, outer pair often cucullate at the apex, subsaccate at the base; petals somewhat large, shortly obovate, very long clawed, yellowish to purplish or white, with brown or violet veins; stamens 6, outer pair little shorter than the inner pairs, anthers oblong, basifixed, filaments dilated; ovary cylindric, style elongated, stigma entire; silique ± turgid, oblong or subelliptic, dehiscent, 1-3 cm. long, with a long ensiform seedless beak; valves concave, 2-veined, septum hyaline, minutely pitted; seeds biseriate, numerous, subglobose or ovoid, 1-2.5 mm. long, pendulous, brown; cotyledons conduplicate.

There are about 5 species in the Mediterranean regions; 1 species is recorded in China.

1. Lower leaves lyrate-pinnatipartite; upper leaves 3-1-paired, terminal lobe ovate, unequally dentate, lateral ones narrow-oblong................ .... *E. sativa.*
1. Lower leaves bipinnatisect, upper leaves 3-paired, terminal lobe elongate, entire, lateral ones linear ....*E. sativa* var. *lativalvis.*

ERUCA SATIVA Gars., Traite Pl. Anim. 2:166, t. 259. 1767.

Brassica Eruca L., Sp. Pl. 667. 1753.
Eruca sativa Mill., Gard. Dict. Ed. 8, No. 1. 1768.
Eruca sativa Lam., Fl. France 2-496. 1778.
Eruca Eruca (L.) Hu, Syn. Chin. Gen. Phaen. 1:216. 1925.

Annual herb, about 1/2 m. high, lower stem purplish, subhispid, upper glabrescent; lower leaves lyrate-pinnatipartite, upper ones 3-1-paired, terminal lobe ovate, unequally dentate, lateral ones narrowly oblong and nearly entire; racemes much elongated, flowers rather large; sepals oblong, about 10 mm. long and 1.5-2 mm. wide, outer pair cucullate at apex; petals twice as long as the calyx, white, brown veined, limb obovate, very long clawed; stamens 6, 10:8 mm. long, filaments dilated; style long and flattened, stigma capitate; silique oblong, erect and appressed, tipped by a stout ensiform beak, half as long as the silique; fruiting pedicel about half in length of the calyx.

Shansi: Wu-tai-shan, Y. *Yabe,* July 16, 1907; Fan-shan-hsien, alt. 2000 m., *K. Ling 1811,* July 30, 1925. "Flowers yellow". (HUN)

Distrib.: This species has been reported from Kwangtung, Yunnan, Shensi, Kansu and Mongolia, but not hitherto known from Shansi.

This species is easily recognized by its silique tipped with a broad ensiform seedless beak.

ERUCA SATIVA Gars. var. *lativalvis* Boiss. Cosson, Comp. Fl. Atlant. 2:209. 1885.

Brassica lativalvis Boiss., Diagn. Pl. Orient. 6:12. 1845.
Eruca lativalvis Boiss., Fl. Orient. 1:396. 1867.

Annual herb, about 20 cm. high; stem erect, simple or branched, covered with simple hairs pointed obliquely downward; leaves glaucous green, glabrous, somewhat succulent, bipinnatisect, lower lateral lobes narrow, lobule unequally pinnatifid; upper ones 3-paired, terminal lobe elongate, lateral lobes linear, entire or nearly so; flowers showy, sepals oblong, 8-10 mm. long and 2-2.5 mm. wide, outer pair cucullate at the apex, pilose; petals yellow, purplish veined, broadly obovate, with a long tapering claw,

less than twice as long as the calyx; stamens 6, 9-10:8 mm. long, anthers oblong, basifixed, filaments dilated, slightly purplish; pistil nearly 10 mm. long, ovary oblong, style ensiform, stigma entire; silique immatured.

Kansu: West of Choni, *J. F. Rock 12179,* June 1925. "Among rocks and on sandy slopes, alt. 8800 ft., flowers yellow."

Distrib.: It is not known else-where.

This variety is characterized by its bipinnatisect leaves which are different from the *lyrate-pinnatipartite* lower leaves of the typical species.

CHEIRANTHUS* Linnaeus

1. Flowers yellow to orange yellow 2
1. Flowers rosy to purple .... *C. roseus.*
2. Plant with erect stem 4
2. Plant with thick branched rootstock, densely covered with withered, straw-coloured, persistent petioles 3
3. Stemless; leaves spatulate, entire; limb nearly orbicular, 6-7 mm. broad; filaments dilated toward the base .... *C. acaulis.*
3. Stem short; leaves spatulate, remotely denticulate; limb obovate, 4-4.5 mm. broad; long filaments broadly membranaceous-dilated .... *C. Forrestii.*
4. Leaves oblong, acute, often entire; silique long, with bilobed spreading stigma at the tip.... *C. Cheiri.*
4. Leaves lanceolate to oblong-linear, acuminate, sinuate-denticulate; silique shorter, with slightly bilobed capitate stigma at the tip........ *C. aurantiacus.*

CHEIRANTHUS ROSEUS Maxim., Fl. Tangut. 57, t. 21, fig. 1-12. 1889.

Perennial herb, with long thick root and striate stem, 12-15 cm. tall, covered with appressed 2-forked hairs all over the plant and with remnants of straw-colored petioles at the base of the stem; leaves lanceolate, thick, acute, tapering toward the base, entire to remotely denticulate, radical leaves long-petioled, 30-70 mm. long, 3-5 mm. broad, cauline ones smaller and short-petioled, upper ones sessile; flowers in terminal raceme, sepals erect, lanceolate to oblong, obtuse, margin membranaceous, white, sparsely hairy outside, 8-9 mm. long, 2 mm. broad, lateral ones narrower and more or less saccate; petals pale, pink to mauve, twice as long as the sepals including a long tapering claw, limb obovate to oblong, rounded, entire or slightly undulate, 5-6 mm. broad; stamens 6, tetradynamous, anthers oblong, filaments broadly dilated, about 6:3 mm. long; pistil linear, compressed, strigose, suddenly abrupted by 2 shallow lobed stigma; pedicels thick, horizontally spreading, 10-5 mm. long.

Eastern Tibet: On rocky cliffs of Kerab valley, southern slopes of Jupar range, *J. F. Rock 14409,* June 1926.

Distrib.: Also recorded in Kansu.

This plant is distinguished from the allied species by its roseus handsome flowers. Two forms of this species, collected by the same collector from the same locality, were recorded as *C. roseus* f. *elatior* (*Rock 14345*) and *C. roseus* f. *caespitosa* (*Rock 14096*). Their remarkable differences observed from both specimens are that the former is a very fragrant and handsome plant, twice as tall as the original species; and the latter is a dwarf one with flowers growing in tufts on a very short terminal raceme.

*Genus description is given in Bot. Bull. Acad. Sinica 2(3): 192. 1948.

CHEIRANTHUS ACAULIS Hand.-Mzt., Pl. Nov. Sin. F. 33, p. 1. 1920-26.

Perennial herb, stemless; rhizome very long, many branched, thick, petioles tufted at each node, straw-like, somewhat hardened; leaves rosulate, spatulate-lanceolate, 10-35 mm. long, 5-6 mm. broad, obtuse, entire or remotely denticulate, thick, with bi-forked appressed white hairs on both sides; scape thick, often 10 mm. long, flowers solitary; sepals erect, oblong, 8-9 mm. long. 2-2.5 mm. broad, rounded, margin membranaceous, sparsely hairy outside, lateral ones somewhat saccate; petals yellow, long-clawed, 16-20 mm. long, limb obovate to nearly orbicular, 6-7 mm. broad, entire or slightly undulate; stamens 6, tetradynamous, anthers oblong, basifixed, filaments broadly dilated toward the base, 6:5 mm. long; ovary linear, strigose, style short, thick, stigma bilobed; pedicels 15-10 mm. long, fruiting ones rigid, erect, 35 mm. long.

Sikang: Mount Mitzuga, west of Muli Gomba, alt. 3050-4875 m., *J. F. Rock 16220,* June 1928 (HUN); Western slopes of Mt. Mitzuga, Muli Territory, alt. 5000 m., *J. F. Rock 24057,* May-June 1932.

Distrib.: Also recorded in Szechuan.

This is a stemless herb with perennial thick rhizome, which is covered by the remnants of straw-colored petioles on each node, and with big yellow flowers and spatulate-lanceolate leaves in rosettes.

CHEIRANTHUS FORRESTII (W. W. Sm.) Hand.-Mzt., Sitzgsanz. Ak. W. W., 65. 1925.

Parrya Forrestii W. W. Sm., Notes Roy. Bot. Gard. Edin. 8:195. 1914.

Short herb, with appressed bipartite or forked hairs; root long, thick, branching; stem more or less woody, subdecumbent, densely covered with withered, straw-coloured, persistent petioles, leafy above; leaves rosulate, spatulate, long petioled, scape short, leafy, flowers axillary and crowded at the tip, lower leaves spatulate, 3-4.5 cm. long, about 0.8 cm. broad, apex acute, base cuneate and tapering into a long petiole; margin entire or remotely few-denticulate, upper leaves much reduced; sepals 8-10 mm. long, oblong, margin membranaceous, erect, lateral ones saccate at the base, sparsely pilose on the dorsal side; petals yellow, 18-20 mm. long, spatulate, spreading limb obovate, 4-4.5 mm. broad, apex rounded, base cuneate and tapering into a long claw; stamens 10:7 mm. long, anthers 2.5-3 mm. long, long filaments broadly membranaceous-dilated; pistil linear, 4-sided, subcompressed, densely covered with appressed hairs, style very short, stigma capitate; examined silique immature.

Yunnan: *G. Forrest 1088,* 1913. (HUN). Yangtze watershed, Prefectural District of Likiang, eastern slopes of Likiang Snow Range, alt. 4300 m., *J. F. Rock 4536,* 1922. (HUN)

CHEIRANTHUS CHEIRI Linn., Sp. Pl. 661. 1753.

Hardy herb, grayish, about 50 cm. high, covered with appressed bipartite hairs; leaves 4-6 cm. long, 0.5-1.2 mm. broad, oblong to broadly linear, acute at the apex, tapering and petioled at the base, margin entire, often bunched beneath the flowers at the end of sterile shoots; flowers very showy, fragrant, yellow or yellow-brown; sepals about 10 mm. long, oblong, erect, margin white-membranaceous, purplish on the dorsal side, lateral ones slightly saccate at the base; petals with slender claw, about 10 mm. long, spreading limb broadly obovate, about 7 mm. long and 8 mm. broad; stamens 6,

nearly equal, about 10 mm. long, filaments dilated; pistil linear, style very short, stigma bilobed; silique 4-7.5 cm. long, linear, angled, compressed, with bilobed spreading stigma at the tip; examined seeds immature; fruiting pedicels 10-6 mm. long, filiform, stout, erect-spreading.

Kiangsu: Shanghai, cultivated in the garden of the Institute, *H. Migo,* May 13, 1931; Nanking, Museum campus, *C. Y. Luh 564,* May 4, 1933. "Cult. herb, flowers yellowish brown." Without precise locality, *T. K. Wang 2249,* May 10, 1918 (HUN); *K. C. Chen 331,* Apr. 15, 1919 (HUN).

N. China: Without precise locality, *Y. Yabe,* May 2-3, 1905.

Szechuan: Chengtu, *C. S. Fan 1071,* Apr. 6, 1938. "Flowers orange yellow." (HUN) Lung-ying-cheng, Chungking, *T. Y. Cheo* et *K. C. Tsu 124,* Apr. 14, 1938. "Herb, cultivated for ornamental use; flowers yellow." (HUN)

Vernacular name: Kwei-chu-shien.

This is a very popular ornamental plant and commonly known as "wallflower."

CHEIRANTHUS AURANTIACUS Bunge, Mem. Acad. Sci. St. Petersb., Sav. Etrang. 2:79 (Enum. Pl. Chin. Bor.) 5, 1831.

Perennial herb, 30-60 cm. high, densely covered with appressed bipartite hairs; stem erect, simple, striate; leaves lanceolate to oblong-linear, acuminate at the apex, base tapering and petioled, upper ones sessile and subamplexicaul, margin remotely sinuate-dentate to subentire; flowers showy, in terminal racemes; sepals about 10 mm. long, narrowly oblong; petals yellow, claw slender, about 10 mm. long, spreading limb obovate to orbicular, 3-8 mm. broad; stamens 6, nearly equal, about 10 mm. long, filaments dilated; pistil linear, 4-sided, compressed, stigma subsessile, slightly bilobed; silique 4.5-8.5 cm. long, with short style and stigmatic end at the tip, valves with an elevated midrib; seeds 1-seriate, oblong, compressed, dark reddish brown.

Kiangsu: Ming-tomb, Nanking, *P. C. Chen 78,* Apr. 27, 1935; Nanking, *C. Y. Chiao 238,* May 22, 1926. "Herb, cultivated in the nursery of Univ. of Nanking, flowers yellow" (HUN); same locality, *C. Y. Chiao 661,* May 23, 1927.

Hopei: Without precise locality, *C. F. Li 10706,* 1929; *C. F. Li 11764,* 1930; Prince Park, Peiping, *T. N. Liou,* June 30, 1930 (HUN); Pai-shih-shan, Lai-yuan-hsien, *K. M. Liou 2662,* July 4, 1934; Po-hua-shan, *T. F. King 50,* June 26, 1936 (HUN); same locality, *T. F. King 357,* Sept. 1936. (HUN)

Shansi: Without locality, *C. D. Reeves,* Aug. 1926; Wu-tai, *T. Tang 1076,* July 13, 1929. "Alt. 2000 m., on open slope, flowers light yellow."

This plant has also ornamental values and is allied to the preceding species from which it differs in leaves with remotely sinuate-dentate margin and acuminate apex.

PEGAEOPHYTON Hayek et Handel-Mazzett

Small, acaulescent, perennial herb, fleshy, often glabrous, with simple, thick, very stout root; leaves rosulate, numerous, linear-lanceolate or spatulate, entire, few-dentate to pinnatifid, tapering at the base into a long flat petiole; scapes numerous, flaccid, as long as or slightly longer than the leaves, with one flower on each scape; flowers large,

pale lilac or white, sepals obovate, obtuse, lateral ones sac-like; petals spatulate, scarcely clawed; filaments simple, slightly dilated; ovary 1-celled, oval, dorsally compressed, style short, thick, stigma truncate, slightly emarginate; silique fleshy, broadly ovate, often oblique by the abortion of seeds above, dorsally compressed, narrowly marginate, contracted into a short stigma; valves slightly convex, thin, 1-veined; seeds usually 8, 2-seriate, compressed, many rooted; cotyledons accumbent.

A montoypic genus confined in the Western China.

PEGAEOPHYTON SCAPIFLORUM (Hook. f. et Thoms.) Marq. et Shaw, Journ. Linn. Soc. Bot. 48:229. 1929.

Cochlearia scapiflora Hook. f. et Thoms., Journ. Linn. Soc. Bot. 5:154. 1861.

Braya sinensis Hemsl., Journ. Linn. Soc. Bot. 29:303, t. 29, 1893.

Pegaeophyton sinense (Hemsl.) Hayek et Hand.-Mazz., Sitzgsanz. Ak. W. W., 246. 1922.

P. scapiflorum (H. f. et T.) O. E. Schulz, Notizb. Bot. Gar. et Mus. Ber.-Dah. 11(103): 229. 1931.

Acaulescent herb, about 5 cm. high, with thick, perennial rootstock; leaves rosulate, numerous, linear-lanceolate or spatulate, with a long flat petiole, entire or with a few sharp teeth, glabrous above, rarely pubescent below; scapes numerous, 1-flowered; sepals obovate, 3 mm. long, lateral ones saccate, margin membranaceous, white; petals white, spatulate, 5 mm. long, apex rounded, truncate or emarginate; stamens 6, filaments broadly dilated toward the base, 3:2.5 mm. long; ovary broadly ovate, compressed, style short, thick, stigma truncate; examined silique immature.

Yunnan: Eastern slopes of Likiang Snow Range, Yangtze watershed, alt. 5200 m., *J. F. Rock 8660,* June 1923. "On limestone." (HUN) Mount Peimashan, Mekong-Yangtze divide between Atuntze and Pungtzera, alt. 5000 m., *J. F. Rock 9968,* July 1923. (HUN)

Eastern Tibet: Alpine region between Radja and Jupar range, *J. F. Rock 14236,* June 1926. "Alpine meadows of Woti-la, north of Radja, alt. 4700 m., flowers white, forming rosettes".

Southwestern Szechuan: Mount Konka, Risonquemba, Konkaling, alt. 3960-5335 m., *J. F. Rock 16859,* 1928. "Flowers white". (HUN)

It is a small stemless herb with a thick perennial root and numerous spatulate leaves in rosettes and solitary flower on each scape.

var. ROBUSTUM O. E. Schulz. Notizb. Bot. Gar. et Mus. Ber.-Dah. 9:477. 1926.

Slender herb, leaves rosulate, large, membranaceous, petiole more than 10 cm. long, lamina broadly linear, entire, about 1.5 cm. wide, apex obtuse to rounded, base tapering; scape slender, about 20 cm. long, each with a single terminal flower.

Yunnan: Mount Lauchunshan, southwest of the Yangtze bend at Shiku, *J. F. Rock 9577* (Co-type), June 1923. "Swampy meadow". (HUN)

var. STENOPHYLLUM O. E. Schulz. l. c.

Herb with thick perennial rootstock, densely covered with gray straw-like withered dilated bases of petioles; radical leaves slender, membranaceous, linear, acute, entire or remotely denticulate, with slender petiole 4.5-8 cm. long, lamina mostly 2-3 mm. broad near the apex. Ripe fruit ovate in shape, 2.5-3 cm. long, 0.5-1 cm. broad, compressed, narrowly marginate; valves leaf-like, obscurely pinnately veined, septum white, membranaceous; seeds 2-seriate, compressed, dark brown.*

Southwestern Szechuan: Mountains north of Baurong and east of the Yalung River, alt. 4770 m., *J. F. Rock 17779,* July 1929. "Flowers white". (HUN). Specimens are in young stage.

Yunnan: Yangtze watershed, Prefectural District of Likiang, eastern slopes of Likiang Snow Range, limestone gravel, alt. 5300 m., *J. F. Rock 5719* (Co-type), 1922.

LOXOSTEMON Hooker f. et Thomson

Small tender herb, rootstock with clustered bulbils; leaves petiolate, basal ones usually solitary, 3-foliolate; cauline leaves few, above the middle of stem, pinnate, leaflets 2-5 paired, small, subpetiolulate, ovate, oblong or linear, terminal ones similar in size, pubescent or glabrescent; flowers several, corymbose, pinkish to purple; sepals small, ovate, obtuse, spreading, equal at the base; petals broadly obovate to spatulate, clawed, less than 3 times long as the calyx; stamens 6, tetradynamous, filaments of the longer stamens broad-membranaceously winged and recureved near the apices; pistil linear, stigma sessile, bilobed; silique linear.

There are about 5 species recorded from India to S. W. China.

LOXOSTEMON DELAVAYI Franch., Bull. Soc. Bot. de Fr. 33:400; Pl. Delav., 56. 1889.

Cardomine Franchetiana Diels. Notes Roy. Bot. Gard. Edin. 5:205. 1912.

Slender herb, 10-15 cm. high, with small clustered bulbils at root-stock; stem simple, thin, glabrous; cauline leaves 2 or 3, pinnate, petiolate, rising from the middle of the stem, leaflets in 4-5 pairs, 3-10 mm. long, 1-3 mm. broad, subpetiolulate, oblong or ovate, somewhat mucronate at the apex, pubescent above and glabrous below or glabrescent with the age; flowers several, corymbose, sepals about 3 mm. long and more than 1 mm. broad, ovate, obtuse; petals purplish, about 8 mm. long, broadly obovate, clawed; stamens 6, longer filaments with broadly membranaceous wings but narrow and recurved at the apices; pistil linear, about 4 mm. long, stigma sessile, slightly bilobed; flowering pedicels filiform, less than 10 mm. long; silique not observed.

Yunnan: Eastern slopes of Likiang Snow Range, Yangtze watershed, alt. 5000 m., *J. F. Rock 9437,* July 1923. "On crevices of boulders". (HUN)

Sikang: Mount Mitzuga, west of Muli Gomba, alt. 3050-4875 m., *J. F. Rock 16252,* June 1928. "Flowers lavender". (HUN)

Distrib.: Also in Szechuan.

According to observations made on the cited specimens, this species is easily recognized by its rootstock with small clustered bulbils and purplish flowers with 4 filaments of the long stamens usually broad-membranaceously winged; while the original description given by Franchet of the species that the filaments of the short stamens have broad-membranaceous wings at the apices. All the other characters are identical. It is well distinguished from its allied species *L. pulchellus* H. f. et *T.* which bears linear leaflets and, rarely in 2 pairs but generally 3-foliate leaves.

DIPOMA Franchet

Perennial herb, with many branches, pubescent-setulose; inflorescence long racemose, peduncles axillary; sepals ovate, erect, hairy on dorsal side; petals subquadrate-orbiculate,

apex broadly emarginate, base contracted into a narrow claw; stamens 6, filaments glabrous, without appendages; ovary obovate, shortly tapering into a long style, ovules 2 in each cell, pendulous; silicle laterally compressed, broadly rhomboid, septum broad; valves small, membranaceous, operculiform, convex, hairy or subglabrous; fruiting pedicels reflexed or in distorted order, seeds solitary in each cell through abortion, cotyledons accumbent. (silicles rarely dimorphic through the abortion of the cell.)

A monotypic genus confined in the Western China.

DIPOMA IBERIDEUM Franch., Pl. Delav. 64, 1889. Tab. 17-A.

Rootstock slender, divided into elongated branches; stem decumbent, subsimple, covered with simple and branched setules, when flowering 10-20 cm. long; leaves thickish, petiolate, lower ones glabrous, upper ones covered with similar hairs as on the stem, spatulate-ovate, tapering and cuneate towards the base, entire or tridentate at the apex, 10-15 mm. long, 2-4 mm. broad near the apex; flowers crowded in racemes, then elongated, pedicels short, hispid, mostly axillary; sepals about 1.5 mm. long and 1 mm. broad, ovate, hispid, greenish white or purple; petals white, spreading limb broadly obovate, emarginate at the apex, cuneate and shortly clawed at the base, about 5 mm. in. diam.; stamens shorter than the petals, filaments scarcely dilated at the middle, anthers violet; pistil small, pear-shaped, stigma depressed capitate; examined silicle immature.

Yunnan: *G. Forrest 5814,* 1910 (HUN); Yangtze watershed, Prefectural District of Likiang, eastern slopes of Likiang Snow Range, alt. 4300 m., *J. F. Rock 4377,* 1922 (HUN), same locality, *J. F. Rock 9878,* Aug. 1923. "On limestone gravel". (HUN)

Sikang: Muli, alt. 4000 m., *G. Forrest 22124,* Aug. 1922. "Straggling plant of 2-4 inches, on open stony meadows, flowers white". (HUN)

var. DASYCARPUM O. E. Schulz. Notizb. Bot. Gar. et Mus. Ber.-Dah. 11 (103): 225. 1931.

The valves of the silicle are densely covered with white long spreading setules. Fruiting pedicels are reflexed and some of them are spiral.

Sikang: Mount Mitzuga, alt. 4600 m., *J. F. Rock 18287* (Co-type), Sept. 1929.

MEGACARPAEA DeCandolle

Large coarse perennial herbs, pubescent or glabrescent, with a thick fleshy root; stems erect, striate; leaves simple, pinnate, basal and lower cauline ones long petiolate, middle and upper ones sessile and amplexicaul; leaflets ovate to ovate-lanceolate, sometimes lanceolate, sessile, variously dentate, incised or lobed, lobes entire, acute, or in larger leaves irregularly dentate; flowers in terminal and axillary racemes or subcorymbs, white, pinkish or violet to purple coloured; sepals equal at the base, ovate to oblong, obtuse, glabrous or slightly pubescent; petals obovate-oblong, narrow at the base, entire or dentate at the apex; stamens 6 or more than 6, filaments not toothed, sometimes dilated; pistil stipitate or not, stigma sessile; silicles large, indehiscent, didymous, compressed, valves obovate to orbicular, broadly margined; seeds large, solitary in each cell, orbicular, much flattened, not winged, cotyledons accumbent.

There are about 10 species in the Central Asia; 3 species are reported in China.

MEGACARPAEA DELAVAYI Franch., Bull. Soc. Bot. de Fr., 33:406, t. 16. 1886.

Perennial herb, 30-70 cm. high, with long thick tap-root; stem erect, striate, densely villous; leaves simple pinnate, more villous on the lower surface and along the rachis, basal and lower cauline leaves long petioled, middle and upper ones amplexicaul-auricled; leaflets sessile, distant, mostly 9 paired, ovate, acute, margin irregularly dentate to lobed; flowers in compound racemes, sepals pinkish, membranaceous, ovate, obtuse, about 4 mm. long, lateral pair more or less saccate, slightly hairy on the dorsal side; petals pinkish to purple, obovate, twice as long as the calyx; stamens 6, nearly equal in length, about 5 mm. long, anthers oblong, filaments purplish, dilated; pistil obcordate; silicle deeply 2-lobed, lobes about 14 mm. long and 8 mm. broad, obliquely obovate, broadly winged, compressed; fruiting pedicels filiform, villous, 7-15 mm. long, reflected or horizontally spreading.

Yunnan: *G. Forrest 10415,* 1913 (HUN); Yangtze watershed, Prefectural district of Likiang, eastern slopes of Likiang Snow Range, alt. 5000 m., *J. F. Rock 5019,* May-Oct. 1922, "alpine meadow" (HUN); same locality, *J. F. Rock 8654,* June 1923, "on limestone boulder". (HUN)

Sikang: Mount Mitzuga, west of Muli Gomba, alt. 3050-4875 m., *J. F. Rock 16528,* June 1928, "flowers purplish lavender". (HUN)

Distrib.: Also in Szechuan and Kansu.

This species is easily recognizable by its thick rootstock, pinkish-purple flowers with 6 stamens, and compressed didymous obliquely obovate fruit with broad margin. The petals of the flowers observed from the above cited specimens are variable at the apices, not at all consistent with the original description given by Franchet, "limbo obovato saepius apice tridentato". The flowers of this plant have ornamental values.

var. MINOR W. W. Sm., Notes Roy. Bot. Gard. Edin. 8:121. 1913.

This small plant (below 30 cm. in height) with very narrow leaflets and saturated rosy flowers can be distinguished from all the others.

Yunnan: *G. Forrest 10326,* 1913. (HUN)

var. GRANDIFLORA O. E. Schulz, Notizb. Bot. Gar. et Mus. Ber.-Dah. 10:557. 1929.

This variety is well distinguished by its pinkish-purple flowers with broadly obovate entire petals up to 1 cm. long.

Southwestern Kansu: T'ao River basin, Mt. Lissedzadza, alt. 4000 m., *J. F. Rock 12597* (Co-type), July 1925. "On grassy slopes with *Rhododendron* and *Juniper,* herb 2 ft. or more, flowers rich pinkish lavender".

f. MICROPHYLLA O. E. Schulz, l. c. 9:476. 1926.

The leaves of this form is obviously smaller than the species as Schulz described it. There is another distinct character worthy of mentioning, that is, most of the petals of the flowers are 3-lobed at the apices and some are 4 to 5 lobed.

Yunnan: Lotueshan, mountains of Labako, west of the Yangtze bend at Skiku, *J. F. Rock 9539* (Co-type), June 1923. "Swampy meadow". (HUN)

Sikang: Mah-geh-jung, north of Noko, alt. 3333 m., *A. Chen Young 187,* July 12, 1934. "On hillside, flowers deep lavender". New record.

f. PALLIDIFLORA O. E. Schulz, l. c. 477.

This form bears pale flowers since Mr. Schulz named this plant. He also described the petals as to be caerulescent or sky-blue, but the color of the petals is pale yellow

on the examined specimen and the sepals are slightly pinkish. The change of color in flowers is common in the preserved specimens, therefore Mr. Schulz is not responsible for this discrepancy. The original diagnosis given by Mr. Schulz seems insufficient, but this plant is quite different at first sight from all its allies, therefore the present form is retained.

Sikang: Muli or Mili Kingdom, 3300-4600 m., *J. F. Rock 5567* (Co-type), June 1922. (HUN)

IBERIS Linnaeus

Annual or perennial plants, mostly glabrous, often more or less woody; stem erect, branching; leaves entire or pinnatifid, sometimes fleshy; flowers white or purplish, in corymbs or lengthening racemes, the outer petals of the flowers are larger than the rest (conspicuous character of this genus); filaments not appendaged or connate; fruit an orbicular or ovate winged or margined silicle, often notched at the top, the septum across the short diameter; seed 1 in each compartment, ovate, not winged on the margins; cotyledons accumbent.

There are 30-40 species naturally distributed in Europe and Asia, mostly in the Mediterranean region, affording popular flower-garden subjects. 1 species was introduced into China under cultivation.

IBERIS AMARA Linn., Sp. Pl. 649. 1753.

Annual herb, somewhat fleshy, about 30 cm. high; stem erect, more or less woody, minutely hairy; leaves oblanceolate, 2-5.5 cm. long, obtuse, glabrous, mostly with few irregularly obtuse teeth near the apices; racemes several, corymbose when young, then elongated; sepals membranaceously marginate, 2 smaller ones about 2 mm. long, 2 larger ones nearly twice as long, minutely hairy on the dorsal sides; petals white, obvate, rounded at the apex, cuneate toward the base, 2 outer petals nearly 2 times larger than the smaller ones; stamens 6, nearly equal; filaments broadly dilated; pistil flask-shaped, about 4 mm. long; flowering pedicels obliquely-horizontally spreading, about 20 mm. long, minutely hairy; immature pod obcordate, with evident style and stigma at the emarginate top.

Kiangsu: Ping-chang-hsiang, Nanking, *C. Y. Chiao,* May 6, 1932. Flowers white; cultivated in Mrs. Steward's garden.

Distrib.: This is an introduced species, not previously reported in China.

This ornamental herb is distinguished from its allied species in having lengthening racemes with white flowers.

SOLMS-LAUBACHIA Muschler

Perennial herb, somewhat shrubby; root thick, often branching and many-headed at the apex, crown covered with dense rudiments of leaves and rosulate radical leaves; leaves thin, membranaceous, linear-lanceolate to oblong-lanceolate, entire, more or less tapering into a long petiole at the base, often glabrous or covered with hairs; flowering stem 1-flowered, longer than the leaves, naked* to covered with white hairs; sepals

ovate-lanceolate to lanceolate, equal at the base, slightly convex, white to reddish margined, pilose, persistent; petals large, blue to rosy, twice as long as the calyx, distinctly clawed; stamens 2-4-6, anthers 4-celled, filaments sometimes short and thickened at the base; silique ovate-oblong, terete to slightly compressed, with convex valves and ovate-oblong septum; style well elongated or nearly none, stigma often distinctly capitate; seeds 2-seriate, 5-8, immarginate; cotyledons incumbent.

There are 4 species confined in the Western China. The flowers of these plants have ornamental values.

1. Pistil with capitate stigma 2
1. Pistil with sub-bilobed stigma 4
2. Leaves fleshy, 1-1.5 cm. broad, petiole 2-3 cm. long .... *S.-L. pulcherrima* var. *latifolia.*
2. Leaves subfleshy, without distinct petiole 3
3. Leaves narrowly oblong-spatulate .... *S.-L. pulcherrima.*
3. Leaves narrowly linear .... *S.-L. pulcherrima* f. *angustifolia.*
4. Silique hairy .... *S.-L. linearifolia.*
4. Silique glabrous .... *S.-L. linearifolia* var. *leiocarpa.*

SOLMS-LAUBACHIA PULCHERRIMA Muschl., Notes Roy. Bot. Gard. Edin. 5:206. 1912.

Perennial herb with torulose rootstock, often branching at the apex, branches densely leafy at the crown; leaves imbricate, appressed against the branches of the rootstock, often slightly curved upwards, upper leaves greenish, subfleshy, oblong-spatulate, 2-3.5 cm. long, 0.5-0.6 cm. broad, often covered with long simple white hairs along the margin and midrib of the lower surface; flowering stem 1-3 cm. long, filiform, covered with similar hairs; flowers bright greenish-blue, fragrant, very showy, solitary; sepals lanceolate, white-margined, about 8 mm. long and 2.5 mm. broad, hairy on the dorsal side; petals twice as long as the calyx, long clawed, spreading limb nearly orbicular or broadly obovate, about 8 mm. broad; stamens tetradynamous, anthers oblong, sub-sagittate at the base, filaments 5:3 mm. long, slightly dilated toward the base; pistil terete, slightly compressed, less than 3 mm. long, stigma distinctly capitate; fruit not collected.

Yunnan: Eastern slopes of Mount Dyinaloko, northern peak of the Likiang Snow Range, alt. 5300 m., *J. F. Rock 9020,* June 1923. (HUN)

Distrib.: Also in Southwestern Szechuan.

This species is easily recognized by its beautiful flowers in greenish-blue color and subfleshy oblong-spatulate leaves, often covered with long simple white hairs along margin and midrib of the lower surface.

var. LATIFOLIA O. E. Schulz, Notizb. Bot. Gar. et Mus. Ber.-Dah. 11: 229, 1931.

This variety is characterized by its fleshy obovate-spatulate leaves with manifest and contracted petiole at 2-3 cm. long and lamina at 2-3 cm. long, 1-1.5 cm. broad.

Southwestern Szechuan: Mount Konka, Risonquemba, Konkaling, alt. 3960-5335 m., *J. F. Rock 16420* (Fruiting Co-type), June 1928. "Leaves large, fleshy, dull green". (HUN)

f. ANGUSTIFOLIA O. E. Schulz, l. c. 9:477. 1926.

This form differs from the species in having narrowly linear leaves of 2-3 mm. broad, and both surfaces more or less pilose or glabrescent.

Yunnan: Yangtze watershed, western slopes of Likiang Snow Range, alt. 4000 m., *J. F. Rock 4277* (Co-type), May 30-June 6, 1922. (HUN)

Sikang: Mount Mitzuga, west of Muli Gomba, alt. 3050-4875 m., *J. F. Rock 16204,* June 1928, "flowers pinkish blue," (HUN); same locality, alt. 4600 m., *J. F. Rock 18296,* Sept. 1929.

SOLMS-LAUBACHIA LINEARIFOLIA (W. W. Sm.) O. E. Schulz, Notizb. Bot. Gar. et Mus. Ber.-Dah. 9:477. 1926.

Parrya linearifolia W. W. Sm., Notes Roy. Bot. Gard. Edin. 11:219. 1919.

Perennial herb with long and thickened rootstock, branching into many heads at the top, often covered with withered leaves below the crown; leaves densely rosulate, 2-3.5 cm. long, 2-3 mm. broad, linear or narrowly spatulate, densely covered with long white hairs beneath; flowering stems radiate from the crown, each 1-flowered, densely covered with similar hairs; immature silique 3.5-5 cm. long, 0.7-1 cm. broad, ovate-oblong, more or less curved, with persistent calyx at the base and subbilobed stigma at the apex, hairy all sides; young seeds nearly orbicular, compressed, 2-3 mm. in diameter.

N. W. Yunnan: Mount Peimashan, Mekong-Yangtze divide between Atuntze and Pungtzera, alt. 5200 m., *J. F. Rock 10020,* July 1923. "Among rocks". (HUN)

Distrib.: Not reported from other provinces.

This species is well distinguished by its hairy linear leaves and hairy ovate-oblong siliques.

var. LEIOCARPA O. E. Schulz, l. c.

This is a very distinct variety in having glabrous fruit.

N. W. Yunnan: Mount Peimashan, Mekong-Yangtze divide between Atuntze and Pungtzera, *J. F. Rock 9304* (Flowering type), June 1923. (HUN)

PUGIONIUM Gaertner

Annual or biennial herb, about 2 m. high, glabrous, intricately branching; leaves fleshy, petiolate, radical ones pinnatisect, withered after flowering; lower cauline leaves pinnatisect, upper ones linear, veins inconspicuous; inflorescence in wide panicled racemes, flowers white or rosy; sepals erect, narrow-oblong, margin membranaceous, lateral pair saccate at the base; petals linear-lanceolate, entire, tapering at both ends; stamens 6, tetradynamous, filaments filiform, anthers narrow-oblong; pistil ± stipitate, ovary winged, 2-celled, ovules solitary in each cell, stigma sessile, depressed capitate; silicle indehiscent, coriaceous, transversely oval, with dagger-like appendages; seeds oblong, embryo exalbuminous; cotyledons incumbent.

1. Fruit with lanceolate wings, 30-35 mm. long, 3-5 mm. broad near base, apex acuminate. . *P. cornutum.*
1. Fruit with hatchet-shaped wings, 15-20 mm. long, 7-8 mm. broad, apex broad-subtruncate and irregular-dentate . . . . *P. dolabratum.*

PUGIONIUM CORNUTUM Gaertn., Fruct. 2:291, t. 142. 1791.

Glabrous herb, somewhat woody, with cylindric to subangular stem, slightly furrowed; cauline leaves fleshy, petiolate, lower ones pinnatisect, segments linear-oblong, entire or irregularily 1-3-dentate or 2-3-lobed at the apex; upper leaves few, lanceolate-linear or linear; flowers in wide panicled racemes, pedicels 10-7 mm. long, then elongated;

sepals 6-7 mm. long, erect, narrow-oblong, margin membranaceous, lateral ones saccate at the base; petals white, twice as long as the calyx, about 2 mm. broad, linear-lanceolate, tapering at both ends; stamens 6, filaments filiform, 6:4 mm. long, anthers about 1 mm. long, narrow-oblong; ovary small, ovoid, winged, stigma sessile, depressed capitate; silicle not fully matured, coriaceous, compressed, with a lanceolate wing on each side, 30-35 mm. long, 3-5 mm. broad near the base, and also often with 4 long spine-like appendages pointed downwards and 2 short ones obliquely upwards; fruiting pedicel filiform, stout, about 2.5 cm. long; seeds not seen.

Shensi: Yulin, near Chengchuanp'u, *W. Y. Hsia 3578,* July 10, 1933. "Plant of 1-3 ft. high, in moist sand, flowers white". (HUN); Yulin, Hungshihsia, alt. 1035 m., *W. Y. Hsia 3646,* July 16, 1933. "Sandy soil, flowers white". (HUN)

Mongolia: Ordos, Ailaitrohan, *W. Y. Hsia 3833,* Aug. 9, 1933. "At moist place in desert; flowers white; vernacular name: Shakai". (HUN)

This species is distinctly characterized by its 2 lanceolate horned fruit and several spine-like appendages.

PUGIONIUM DOLABRATUM Maxim., Bull. Acad. Petersb. 26:426. 1880.

This plant differs conspicuously from the preceding species in having fruit with hatchet-shaped wings, 15-20 mm. long, 7-8 mm. broad, apex broad, subtruncate, and irregular-dentate; and in having the little broad and some 1-3 acute-dentate appendages at the apex. The long filaments of the stamens are about 7 mm. long and the pistil is distinctly stipitate. The other characters are similar. Foliage is not seen.

Mongolia: Ordos, Changmuser, alt. 1400 m., *W. Y. Hsia 3872,* Aug. 17, 1933. "At moist place in desert; flowers with pink petals, greenish at base". (HUN)

ERYSIMUM Linnaeus

Herbs, often hoary, with appressed bipartite and forked hairs; leaves linear or oblong, entire or sinuate-toothed, acute or acuminate at the apex, tapering at the base; flowers yellow or orange, rarely purple, ebracteate; sepals erect, equal or the lateral ones gibbous at the base; petals spatulate or obovate, long clawed, slender; stamens 6, tetradynamous or nearly equal, filaments simple, filiform or dilated; pistil linear, style short or long, stigma 2-lobed or capitate; silique elongate, narrow, compressed, tetragonal or terete; valves linear, 1-nerved, frequently keeled; septum membranaceous or corky; seeds numerous, 1-seriate, oblong, not margined; cotyledons incumbent.

There are about 90-100 species, chiefly European and Oriental; about 15 recorded in China.

This genus is in many respects intermediate between *Cheiranthus* and *Sisymbrium,* differing technically from *Cheiranthus* in the incumbent rather than accumbent cotyledons and usually have more angular siliques than *Cheiranthus.*

1. Plant with larger flowers, petals glowing yellow 2
1. Plant with smaller flowers, petals light yellow; silique with minutely forked or stellate hairs...... .... *E. cheiranthoides.*
2. Leaves loosely arranged, 3-5 cm. long, 2.5-4 mm. broad........................ *E. Benthamii.*
2. Leaves closely arranged, 6-8 cm. long, 4-5 mm. broad......................... *E. sinuatum.*

Erysimum cheiranthoides Linn., Sp. Pl. 661. 1753.

Hoary herb, with appressed forked hairs; stem simple or branching; leaves lanceolate to linear, entire or slightly sinuate; flowers small, sepals 3-5 mm. long, linear; petals yellow, 5-8 mm. long, with very narrow and slender claw, spreading limb narrowly obovate, 1-2 mm. broad; stamens 6, nearly equal, 4-8 mm. long, filaments slender, filiform or slightly dilated; pistil linear, stigma sessile, depressedly capitate; silique about 2.5 cm. long, tetragonal or terete, valves 1-nerved, frequently elevated, scattered with minutely stellate hairs; seeds 1-seriate, small, light brown.

Kiangsu: Nanking, *L. F. Tsu 340,* Apr. 20, 1921. (HUN)

Anhwei: Nanhsuchow, *J. B. Griffing,* May 31, 1922. (HUN)

Hopei: Ling-shou-hsien, *K. S. Hao 3140,* May 8, 1932. (HUN) Y-hsien, alt. 100 m., *K. M. Liou 1918,* May 17, 1934. (HUN)

Yunnan: Between Likiang, Youngning, and Youngpei, on the road to Muli, alt. 3300-4000 m., *J. F. Rock 5175,* May-June 1922. (HUN)

Distrib.: Also reported in Shensi and Szechuan.

This species is quite variable in foliage among the specimens observed above.

Erysimum Benthamii P. Monnet in Lecomte, Not. Syst. 2:242. 1912.

Hoary herb, about 25 cm. high, with appressed 2-3-parted hairs; leaves 3-5 cm. long, 2.5-4 mm. broad, linear, acuminate at the apex, tapering and petioled at the base, upper ones subsessile, margin remotely denticulate; flowers in terminal racemes, crowded, not elongate; sepals about 5 mm. long, erect, oblong, margin white-membranaceous, with elevated midrib on the dorsal side; petals bright orange, about twice as long as the calyx, long clawed, spreading limb obovate, about 3 mm. broad, with wavy margin; stamens 6, 5: 4.4 mm. long, long filaments broadly dilated toward the base; pistil about 5 mm. long, linear, stigma sessile, capitate; fruit not seen.

Sikang: Muli Kingdom, Mount Siga, northeast of Kulu, alt. 3380 m., *J. F. Rock 17928,* June 1929. "Flowers orange". (HUN) Sha-dui, 60 li south of Kauze-hsien, alt. 3700 m., *A. Chen Young 147,* June 25, 1934. "On hillside, flowers bright orange".

This species is distinguished from the allies by its narrower and shorter linear leaves which are loosely arranged on the stem.

Erysimum sinuatum (Franch.) Hand.-Mzt., Sym. Sin. 7 (2): 357. 1931.

E. cheiranthoides L. var *sinuatum* Franch., Plt. Delav. 63. 1889.

Hoary herb, over 30 cm. high, erect, branching, with appressed bipartite hairs; leaves 6-8 cm. long, 4-5 mm. broad, linear or narrowly linear-lanceolate, acute, lower ones tapering and petioled at the base, upper ones subsessile, margin subentire or remotely denticulate; racemes terminal and axillary, sepals about 8 mm. long, oblong, lateral ones twice as broad; petals glowing yellow, spatulate, claw about 8 mm. long, spreading limb about 7 mm. long and 4 mm. broad; stamens 6, 13:9 mm. long, long filaments slightly dilated; pistil linear, 4-sided, style short, stigma depressedly capitate; examined silique immature.

Yunnan: Mount Peimashan, Mekong-Yangtze divide between Atuntze and Pungtzera, *J. F. Rock 9258* (*E. bracteatum* W. W. Sm.), June 1923. (HUN)

MATTHIOLA or MATHIOLA R. Brown

Annual, biennial and perennial herbs, or subshrubs, with hoary and branched hairs, sometimes stellate; leaves entire or sinuate; flowers large, purple, rosy, or white, not true yellow, in terminal racemes; sepals erect, narrowly oblong, lateral saccate at the base; petals spreading, long-clawed; fruit a long silique, narrow, terete or compressed, septum thick; stigma manifestly 2-lobed and the lobes either spreading or thickened on the sides and decurrent down the style; seeds 1-seriate, flattened, with a narrow membranaceous wing; cotyledons incumbent.

There are about 50 species or more, natives of the Mediterranean region, Arabia and Western and Central Asia; 1 species is commonly cultivated in China.

MATTHIOLA INCANA (L.) R. Brown, Ait. Hort. Kew. ed. 2, 4:119. 1912.

Cheiranthus incanus Linn., Sp. Pl. 662. 1753.

Biennial herb, erect, hoary, felty-pubescent with multi-branched hairs; stem more or less woody at base; leaves oblong to oblanceolate, obtuse, entire or wavy; flowers in long racemes, terminal and axillary; sepals 11-15 mm. long, 2-4 mm. broad, oblong, acute, margin membranaceous-white, densely felty-pubescent on the dorsal side, lateral ones somewhat saccate at the base; petals purple, pinkish or white, broadly obovate, retuse, entire, long-clawed (10-13 mm. long), spreading limb 15-18 mm. long, 10-13 mm. broad; stamens 6, tetradynamous, anthers oblong, long filaments broadly dilated toward the base, short ones slightly curved, cylindrical; pistil oblong, compressed, felty-pubescent, suddenly terminated by v-shaped lobed stigma; pedicel erect-spreading, 20-15 mm. long; fruit not seen.

Hopei: T'u-ti-miao, Peiping, *C. W. Chang*, Apr. 1928. "Cultivated."

Kiangsu: Nanking, cultivated in the garden of Univ. of Nanking, *I. Tang 15*, Mar. 24, 1926. "Flowers purple". (HUN). Shanghai, *T. Y. Cheo 1503*, Mar. 1949.

This plant is cultivated for ornamental purposes in the flower-gardens. It is commonly known as "Stock". It is very popular in the flower-shop or nursery in Shanghai.

BRAYA Sternberg et Hoppe

Small tufted glabrous or hoary pubescent alpine perennials, with a thick branching rootstock; leaves mostly radical, spatulate or linear, fleshy, entire or remotely toothed; flowers purple, rosy or white, solitary or racemed, naked or bracteate; sepals erect-spreading, oblong-ovate, apex obtuse, base not saccate, broadly hyaline-marginate; petals obovate, more or less truncate or emarginate at the apex, cuneate into a narrow claw at the base; stamens 6, filaments linear, anthers short, cordate, obtuse; pistil broadly cylindric or bottle-shaped, ovary with 4-26 ovules, style short, stigma depressedly capitate; fruit short, linear, oblong, subcylindric or slightly compressed, dehiscent; valves convex, apex rounded, base obtuse, 1-nerved; seeds usually 2-seriate, few or many, ovoid, immarginate; cotyledons incumbent.

There are about 11 species in the high mountains of Europe and Asia; about 6 species recorded in the alpine regions of China.

1. Tufted herb with short scape, densely villous up to the pedicels; flowers ebracteate; all radical leaves linear .... *B. Forrestii?*
1. Tufted herb, without scape; flowers bracteate 2
2. Cauline leaves spatulate, 4-5-verticillate; stem glabrous .... *B. verticillata.*
2. Cauline leaves few, oblong-linear; stem minutely pubescent........ *B. oxycarpa.*

BRAYA FORRESTII W. W. Sm. ?, Notes Roy. Bot. Gard. Edin. 8:119. 1913.

Perennial herb, densely tufted; root stout, fleshy, long and many-headed, densely scaly with grey withered dilated persistent petioles at the top; all radical leaves linear, subfleshy, about 14 mm. long, 1 mm. broad, acutish, sparsely pubescent or glabrous; scape very short, leafless, densely covered with brown reflexed long weak hairs; raceme several flowered, corymbose, ebracteate, pedicels pubescent with similar hairs as on the scape; sepals about 2 mm. long, 1 mm. broad, elliptic, distinctly white-marginate; petals white or pinkish, nearly twice as long as the calyx, obovate, base tapering into a narrow claw; stamens 6, 2.5:1.5 mm. long; pistil very small, flask-shaped, style 1/2 mm. long, stigma depressedly capitate; fruit not seen.

Yunnan: Yangtze watershed, western slopes of Likiang Snow Range, alt. 4300 m., *J. F. Rock 4208,* May-June 1922. (HUN)

Distrib.: Also recorded in Szechuan.

The above examined specimen is not very well represented, and its characteristics are not at all in agreement with the diagnosis given by Smith, therefore the present species is somewhat doubtful. Although it is closely related to *B. aenea* Bunge and *B. tibetica* H. f. et T.; yet it differs from the former by bearing leaves often bronze-like in color and having the apex of the petal often denticulate, and from the later in having petals hardly exceeding the sepals.

BRAYA VERTICILLATA (Jeffrey et W. W. Sm.) W. W. Sm., Notes Roy. Bot. Gard. Edin. 11:202. 1919

? *Cardamine verticillata* Jeffrey et W. W. Sm., l. c. 8:120. 1913.

Slender perennial herb, glabrous, about 10 cm. high; root thick, long, runner-like when young, with few small scale-like leaves and grey dilated persistent petioles at the top; stem solitary, thin; leaves fleshy, spatulate, 4-5-verticillate, located 1-2 cm. below the inflorescence, 5-8 mm. long, 3-4 mm. broad, apex rounded, base attenuate, margin entire, veins indistinct; flowers densely racemed, bracteate, pedicels 6-3 mm. long; sepals about 3 mm. long, 2 mm. broad, ovate-oblong, obtuse, margin hyaline; petals white, 6-8 mm. long, 4-5.5 mm. broad, obovate, more or less truncate or emarginate at the apex, cuneate into a narrow claw at the base; stamens 6, nearly equal, about 4 mm. long, filaments little broader near the base; pistil pear-shaped, tapering upwards, stigma small, depressedly capitate; fruit not yet mature.

Yunnan: Bei-ma-shan, *G. Forrest 19586,* June 1921. (HUN) "Plant of 3-5 inches, on ledges of cliffs, alt. 4700 m., flowers white or white flushed rose-purple".

This species is characterized by the whorled leaves and the bracts, but by the absence of mature fruit and older plant, its affinity is still doubtful. The general habit of this young plant is quite similar to *Dipoma iberideum* Franch. (*G. Forrest 5814,* 1910.) from which it differs in destitution of pubescence and with whorled leaves.

BRAYA OXYCARPA H. f. et T., Journ. Linn. Soc. 5:169. 1861.

B. rubicunda Franch., Bull. Soc. Bot. de Fr. 33:403, 1886 et Pl. Delav. 62. 1889.

Small tufted herb; perennial root thick, branching, with white scariose dilated persistent petioles at the top; flowering stem 2-3 cm. high, erect, simple, slender, purplish, leafy on the upper part, densely pubescent with simple to 2-forked short hairs up to the pedicels; basal leaves dry up after flowering, crowded, narrowly obovate-spatulate, obtuse, petioled; cauline leaves few, oblong-linear, obtusish, cuneate-narrowed to subsessile at the base, upper ones bearing flowers in the axils, all leaves small, fleshy, with entire margin, glabrous or sparsely pubescent; racemes short, with several flowers; sepals 2 mm. long, ovate, margin hyaline, glabrous; petals 4.5-5 mm. long, white at first, lilac or reddish later, obovate, rounded to scarcely emarginate at the apex, narrowed into a claw at the base; stamens 6, nearly equal, about 3 mm. long, slightly broader toward the base; ovary ovate, glabrous, style short, stigma minute, depressed; fruit not seen.

Yunnan: Yangtze watershed, western slopes of Likiang Snow Range, Alt. 4300 m., *J. F. Rock 4250,* May-June 1922. (HUN)

Distrib.: Also reported from N. Szechuan.

The above observed specimen is a very small young plant which differs from the preceding species in having purplish stem densely covered with short slender hairs up to the pedicels and few small alternately arranged leaves.

HEMILOPHIA Franchet

Perennial herb with many slender rootstocks and diffuse branches; leaves scattered, petiolate, small, entire; flowers few, axillary; sepals ovate, concave, base often saccate, erect; petals long cuneate, apex 2-lobed; stamens 6, filaments glabrous, longer ones thickened at the base; ovary slightly and laterally compressed, base broadly truncate to slightly obcordate, slightly tapering, apex obtuse; style thick, conical, stigma depressed; ovules solitary in the cell, oblong, pendulous; silicles broad-pyramidal, dehiscent; valves oblong, boat-shaped, with few obtuse warty crests below the middle along the margin and on the dorsal surface; seeds obovate-oblong; cotyledons incumbent.

This genus is endemic in the Southwestern China; 2 species are recorded in Yunnan and Sikang.

1. Plant manifestly strigose-pilose; leaves with petiole 10-6 mm. long ....*H. pulchella* var. *pilosa.*
1. Plant densely covered with minute, hoary, flabby hairs; leaves with petiole 6-3 mm. long...*H. Rockii.*

HEMILOPHIA PULCHELLA Franch. var. *pilosa* O. E. Schulz, Rep. sp. n. 17: 290. 1921.

Small herb with filiform diffuse decumbent hairy stems, 5-10 cm. high; leaves obovate-spatulate, entire, manifestly strigose-pilose on both sides, together with petiole 10-6 mm. long; flowers showy, axillary, several near the tip of the branches; sepals about 2 mm. long, ovate, violet, with white broadly membranaceous margin, pilose on the dorsal side; petals white to violet, twice as long as the sepals, broadly obovate, apex 2-lobed, base cuneate and clawed; stamens half as long as the petals; pistil terete, about 2 mm. long, stigma depressed; silicles not yet mature, valves with warty crests along the margin and on the dorsal surface.

Yunnan: *G. Forrest 5911,* 1910 (HUN); Yangtze watershed, Prefectural District of Likiang, eastern slopes of Likiang Snow Range, alt. 4000-5000 m., *J. F. Rock 4691,* 1922 (HUN); same locality, *J. F. Rock 5426,* 1922 (HUN).

This variety is easily distinguished from the type species in having strigose pilosity.

HEMILOPHIA ROCKII O. E. Schulz, Notizbl. Bot. Gart. Berl. 9:476. 1926.

Small and slender herb, with many diffuse decumbent stems, densely covered with hoary thin crested hairs up to the pedicels; leaves scattered, very small, narrowly obovate or sub-oblong, 6-3 mm. long, 1.5-1 mm. broad, with more or less simple flabby hairs; flowers axillary, showy; sepals about 2 mm. long, ovate, more or less denticulate above the middle of the margin, pilose on the dorsal side; petals white, then pale violet, about 5 mm. long, broadly obovate, 2-lobed or emarginate at the apex, cuneate and clawed at the base; stamens nearly equal, inner filaments manifestly obtuse toothed-dilated near the base; pistil small, flask-shaped, stigma subcapitate; silicle very young.

Sikang: Mountains between the Litang and Yalung rivers, between Muli Gomba and Baurong and Wa-Erh-Dje, alt. 4600 m., *J. F. Rock 16712,* July 1928. "Flowers white." (HUN)

This species is characterized by its pubescence of minutely hoary flabby crested hairs on stems up to the pedicels and inner filaments of the stamens manifestly obtuse toothed-dilated near the base.

ANATOMY OF THE WOOD OF MANGLIETIA MOTO DANDY, WITH SPECIAL REFERENCE TO ITS VESSEL MEMBERS

T'IEN-HSIANG HO

A vessel member is defined as one of the perforated cellular components of a vessel (20, 24), it has two perforation plates in opposite walls (24), but there is no wall partitioning the member cavity. In the secondary xylem of *Manglietia Moto* Dandy (12), the writer found from one to several "septa" like membranes (figs. 3-7, 9) traverse transversely across the member cavity. Since "septum" is unknown to the woody vessels therefore it is worth-while to report on the succeeding pages the anatomy of the wood and the structure of the "septa," for neither McLaughlin (23) has examined in this genus *Manglietia* nor Tang (31) has noted in the species *M. Fordiana* Oliv. respectively.

Anatomical technique used by Brown (3) and Franklin (16, 17) for woody preparation was adopted. Record and Chattaway's (26) listed anatomical features were in general followed to describe the structural pattern of the present wood; other works (5, 11, 15, 20, 24, 32) were also consulted.

In the study of the variations in cell size and variations in the proportion between the total area occupied by the vessels and the area occupied by the other cells, the effect of different methods of sampling and measuring recommended by the earlier workers (4, 6, 7, 8, 9, 10, 13, 14, 28, 29) has been compared with and adopted as the follows:

MATERIAL AND METHOD

Specimen examined: Manglietia Moto Dandy—Lo-ch'ang, Northern Kwangtung, Lat. 25° 08' N., Long. 113° 18' E., Northern Village, Plum Valley, alt. 500 m., in dense woods by a brook, *S. H. Chun 3216* (in herb. Bot. Inst., Sun Yat-sen Univ.; Det. Y. Tsiang), May 3, 1943 (straight tree, height 20 m.; flower bracts greenish, pubescence yellow).

The material examined is a log. The diameter of the disc is 21 cm. from west to east or 24 cm. from north to south. Six samples, from which a total of 36 T.S., 32 R.L.S. and 62 T.L.S. were obtained (3, 17, 19), were taken from two wood sticks cut out from the log in the opposite directions at the same plane from the disc and parallel with the pith vertically. The distance from the periphery of the pith (14, 28) to the stick S. is 11.5 mm. long, beginning at the 9th growth ring, while stick N. is 10 mm. long at the 10th.

Width of growth rings: All rings in two microtome sections representing the gross samples were measured at a magnification of 30 X. The mean, $\overline{x}$, and the standard deviation, s (30), of ring width were calculated.

Size for pore diameter: To make the number of measurements convenient in a representative sample (14) and to make the successive observations easy, a definite area in a selected section is set out for special examination. These areas were mostly selected in a ring of regular growth from each of the many samples chosen. At a magnification of 200 X (14) each solitary pore (14) was measured in sequence along a narrow radial strip (6). The $\overline{x}$, s and e (standard error, 30) of the tangential diameter (6, 9, 11, 15, 22, 32) were obtained from at least 100 measurements each (6) grouped into 5 μ classes (14). The maximum diameter (26) and the shape of the pores (9) also were given. (24, 28, 29.)

Pore (vessel) area: Desch's (14) method for measuring the proportion of vessels per unit area was followed here in the pore area determinations. In addition to the ring area and percentage of pores by area (14), enumeration of the mean proportion (30) was supplied to express the grouping of the pores (29).

Intervascular pitting: Main axis of the largest pittings of the largest early wood vessel elements was measured and consequently an average was obtained. (11, 15, 26, 32.)

Length of vessel members: The standard method in measuring the length of the vessel members is the one recommended by Chalk and Chattaway (7), that is to measure the total member length on macerated material. Vessel elements of common lengths selected from both the inner and outer parts of the growth layer were macerated and measured (8). In addition to the $\overline{x}$, s and e of the member length, the range was also calculated by the formula given by them. The tail length and the axial height of the perforation plate were measured at the same time, the percentage of overlap was obtained (8). 100 measurements of each feature were made from six samples. Regarding the number and spacing of the bars (24), 50 perforation plates were selected along the growth rings of several radial longitudinal sections for counting the number, and 1 measurement was made at the middle spacing of each plate.

Size for ray width: With respect to the size for ray width, only the ray surrounded by the wood fibres (6, 9, 24) belonging to the early wood portion was considered. The maximum ray width measured in terms of microns (6, 9), and the width counted in terms of number of cells (9, 11, 15, 26, 29, 32). 50 scattered rays were measured and calculated. 150 rays, originated from more than one ray initial, were counted from the selected areas in the transverse succession, and the mean proportion was obtained to show the frequency of different sizes.

Size for ray height: Except the vertically fused rays (15), the height of a ray was expressed in terms of number of cells (26, 29) and recorded in terms of microns (9, 11, 15, 26, 29, 32). The

rays examined are at their normal size (6, 9, 24) of the early wood in the area in the transverse succession as mentioned above. 150 rays were counted and 50 measured. The $\bar{x}$, s and e of ray height were calculated and the maximum height (26) noted respectively.

Number of rays: Rays were counted in the tangential succession in the tangential sections (9, 26). Early and late wood sections were examined in an area of 2 mm. diameter (15) each and an average was obtained.

Ray-vessel pitting: In the early wood portion, the tangential diameter (26) of 50 largest pittings in the rings of regular growth was measured and calculated. (11, 15, 32.)

Size and number of fibre pits: Main axis of the largest pits in the late wood portion was measured. In the same area the number of pits per sq. 0.1 mm. was counted. Both averages were obtained. (25, 26, 32.)

Thickness of fibre walls: Chattaway's (9) method in measuring the ratio between the lumen to the wall thickness was adopted. At a low magnification the representative areas were selected in the late wood which belongs to the ring of regular growth. Radial pair of fibre cells free from the pores was measured in the transverse succession. 50 measurements were given to several different areas, each of which represents a ring from each sample. Both values of the radial width of the lumen and the combined thickness of the walls were calculated respectively. (11, 15, 26, 32.)

Length of fibres: Small tangential chips (14) representing the early wood, the late wood and the portion passing through the ring boundary were chosen in six samples and macerated (16) respectively. At a magnification of 80 X, fibres, free from the pressure exerted by the swelling vessels and other factors (10), of common lengths were measured. A total of 100 measurements (29 Table II) were made and the $\bar{x}$, s and e of the fibre length calculated. (4, 9, 13, 21.)

OBSERVATION AND CALCULATIONS

Growth Rings. Present: ring width 2.58 ($\bar{x}$), 1.15 (s) mm.—*rings* 12. Double rings present.

Vessels. Diffuse-porous: radial-echelon in arrangement (fig. 1), solitary pores 50.4% and radial 20.7%, tangential 8.7%, oblique 7.4% and the rest of 12.8% (fig. 1) belonging to 2- (24.0%), 3- (14.0%), 4- (7.4%), to 8- (0.4%) celled groups—*area* 4.97 mm.^{2}

Solitary pores polygonal (fig. 2a) to elliptic polygonal (fig. 2b) in shape, tangential diameter 45.43 ($\bar{x}$), 8.12 (s), 0.74 (e) μ, up to 68.80 (maximum) μ—*area ibid.*

Individual pores of groups not crowded laterally; 94.9 pores per sq. mm. (Clarke 11, F.P.R.L. (England) 15)—*area ibid.*

Pore area 15.9%—*rings* 12th S. and 13th N., *ring area* 2.40 mm.^{2}

Vessel contents lacking. Spirals and striations lacking.

"Septa" present (figs. 3, 4a), 94.6 per cent: being 1 (23.3%), 2 (40.0%), 3 (23.3%), 4 (5.7%), or 5 (2.3%) in a member cavity—*vessel elements* 300 in macerated material; bearing no relation to the ray (figs. 5b, 7b) or wood parenchyma, transverse (oblique), extending only to the inner surface of the member wall (figs. 4b, 6b, 7b), resembling those of septate fibre-tracheids (figs. 14b and c, 15b), concave (figs. 4b, 7b) or not, thin, irregularly perforated (figs. 5a-7b).

Pits predominantly linear and parallel (fig. 8a and b), main axis 47.60 μ to opposite (fig. 8a), main axis 8.05 μ.

Perforations multiple (fig. 3), plates elliptic (fig. 9), oblique (fig. 6a), scalariform (figs. 6a, 9); number of bars per plate 6.5, 1.8, 0.3 bars, thin, generally unbranched (figs. 6a, 9), spacing between bars 11.14, 2.59, 0.37 μ.

Total member length 915.97, 148.58, 14.86 μ, theoretical range 1033.21 μ; tail length 98.92, 71.17, 7.12 μ, axial height of the perforation plate 71.89, 22.35, 2.23 μ, and the percentage of overlap 29.4%.

WOOD PARENCHYMA. Present, apotracheal: terminal, 2 (3) cells wide (fig. 10); diffuse to a narrow band in the late wood.

Cell walls fairly uniform (Record 24).

Pit-pairs between two parenchyma cells usually small, irregularly shaped and clustered; pits to vessel elements half-bordered, elongated and scalariformly arranged, but failing virtually to form pairs with the septate fibre-tracheids.

RAYS. Not definitely two-sized (fig. 8a), large and aggregate rays lacking, vertically fused rays present.

Heterogeneous (figs. 8a, 10): both types of procumbent and upright (square) cells present in all of the rays, the two types of cells in separate strata (tiers) (Record and Chattaway 26; fig. 8a); marginal tiers of upright (square) cells usually of intermediate height (conspicuously high) at either end, or of intermediate to one cell high at both ends, of the multiseriate middle layer (early wood portion), associated uniseriate rays composed commonly of upright cells (or of two types in tiers); uniseriate margins frequently no wider than biseriate strata of the procumbent cells.

Cell walls thin; the end, the upper and lower walls indistinctly pitted.

Sheath cells, tile cells, latex or other tubes, and special enlarged cells lacking.

Maximum ray width 33.46, 4.61, 0.65 μ; uniseriate 25.3%, 1-2 -celled 38.7%, biseriate 17.3% and 2-3 -celled 18.7%. Ray height 12.6, 6.1, 0.5 cells, up to 31 cells; or 360.48, 182.74, 25.83 μ, up to 738.56 μ. 10.5 rays per mm.

Ray-vessel pitting (figs. 11-12): pit outline predominantly much elongated, partially narrowly bordered, more or less scalariformly arranged, tangential diameter 39.65, 4.58, 0.65 μ; pit-pairs in part unilaterally compound (fig. 11a and b), smaller pits lenticular to short oval, 2-9, horizontally arranged.

Pits sometimes present in the facets of the wall adjoining the septate fibre-tracheids (late wood portion; cf. fig. 13), ellipsoid or broad ellipsoid, oblique, narrowly or distinctly bordered (main axis of the latter up to 7.0 μ), apertures lenticular, extended (5.6 μ long) or linear, included.

TRACHEIDS AND WOOD FIBRES. Vasicentric and vascular tracheids lacking. Fibriform vessel members lacking.

Septate fibre-tracheids (Harrar 18; figs. 7a, 8a, 10, 14a, 15a) generally present: pits distinctly bordered (figs. 6a, 14b and c), circular (ellipsoid) to circular-ellipsoid, inner apertures narrowly lenticular (slit-like), included (extended), obliquely inclined, appearing in the form of an X (V), main axis 5.86 μ, 28.2 pits per sq. 0.1 mm.; septa transverse, concave (figs. 14b, 15b) or not, very thin, unpitted or minutely pitted (fig. 14b).

Spiral thickenings lacking; the inner layer of the wall in part gelatinous, staining reactions (Rendle 27) sporadic.

Fibre-tracheid length 1632.00, 218.66, 21.87 μ; combined thickness of the walls 9.21, 1.54, 0.22 μ, radial width of the lumen 20.14, 3.74, 0.53 μ.

Intercellular Canals. Lacking.

Storied Structure. Lacking.

Crystalline Cell Contents. Absent.

Special Features. Lacking.

DISCUSSION

The structural character of the vessel members of *Manglietia Moto* Dandy agrees in general with that of the less specialized types of dicotyledonous secondary xylem as studied by Bailey (1) but the general presence of perforated, "septum-like" membrane (figs. 3-7, 9) is distinct. The membrane has no relation to the ray (figs. 5b, 7b) or to the wood parenchyma. Sometimes the member wall between each two "septa" disappears partially (figs. 3, 4a). It is true these vessel members are the components of a vessel (sensu stricto, ex I.A.W.A. 20) belonging to the category of extant representatives of the Dicotyledons. It can not be compared with that of the vesselless woods of the Dicotyledons, for the vesselless arboreal dicotyledonous woods as we know to-day are limited to the nine surviving genera (2). On the other hand, the formation of the matrix of the wood by the septate fibre-tracheids is a very common phenomenon. It is worth-while to consider that whether this type of the vessel elements of *Manglietia Moto* be interpreted as an illustration of truly phylogenetic derivations of the septate fibre-tracheids, or it is only a kind of divergent specialization, there is not enough data to provide a reliable basis for phylogenetic generalization as Bailey (1) has postulated.

SUMMARY

A new morphological type of vessel member in the wood of *Manglietia Moto* Dandy is reported.

The structural pattern of the wood mentioned is described in detail.

A review of different methods, recommended by other workers, in sampling the material and measuring the dimensions and proportions of various woody elements has been made for the present study in order to suggest a modified method for recording the diffuse-porous woods in general.

In conclusion the writer has much pleasure in thanking Dr. F. H. Wang, in charge of the Morphological Laboratory of the Institute, for his kind help and encouragement.

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EXPLANATION OF FIGURES

(T.S. = Transverse section; R.L.S. = Radial longitudinal section; T.L.S. = Tangential longitudinal section; M.M. = Macerated material.)

All figures show *Manglietia Moto* Dandy.

Fig. 1. T.S. X 14, A portion of a growth ring showing the arrangement and occurrence of the pores.

Fig. 2a & b. T.S. X 184, Two solitary pores, each with its surrounding septate fibre-tracheids, showing the typical shapes. Note also the surroundings.

Fig. 3. M.M. X 38, A complete vessel element showing its outline and the occurrence of "septa."

Fig. 4a. MM. X 38, Another complete vessel element showing its outline and the occurrence of "septa."

Fig. 4b. Ibid. X 184, A portion of the cell showing the shape of the "septa." (Cf. figs. 6-7.)

Fig. 5a. T.S. X 184, A group of cells showing five vessel elements, except the central one, having a perforated "septum" at different foci respectively.

Fig. 5b. Ibid. X 426, The same as 5a showing the left "septum" bearing no relation to the ray. (Cf. fig. 7b.)

Fig. 6a. R.L.S. X 184, A portion of a vessel and its surrounding cells showing the perforated "septum" lying over a scalariform perforation plate. Note also the bordered pits of septate fibre-tracheids.

Fig. 6b. Ibid. X 426, The same as 6a showing the "septum" only, the septae fibre-tracheids are not in view.

Fig. 7a. T.L.S. X 184, A portion of a vessel element and its surrounding cells showing the perforated "septum" neighbouring with a ray. Note also the shape of the ray cells and the septa of two septate fibre-tracheids, respectively.

Fig. 7b. Ibid. X 426, The same as 7a, showing the perforated "septum" bearing no relation to the ray. (Cf. fig. 5b.) Note also the end wall of a ray cell.

Fig. 8a. T.L.S. X 38, A portion of a growth layer showing the intervascular pitting and the form and arrangement of the rays.

Fig. 8b. Ibid. X 426, A portion of a vessel element showing the scalariform pitting only.

Fig. 9. M.M. X 184, A complete vessel element showing the pittings on its radial facet. Note also the two scalariform perforation plates.

Fig. 10. R.L.S. X 38, A portion of two succeeding growth layers showing a heterogeneous ray passing through the ring boundary. Note also the wood parenchyma strands (WPS).

Fig. 11a & b. R.L.S. X 426, Two cross-fields each showing the ray-vessel pitting between the procumbent ray cell and the vessel element in the early wood.

Fig. 12 R.L.S. X 426, A cross-field showing the ray-vessel pitting between an upright ray cell and the vessel element in the early wood.

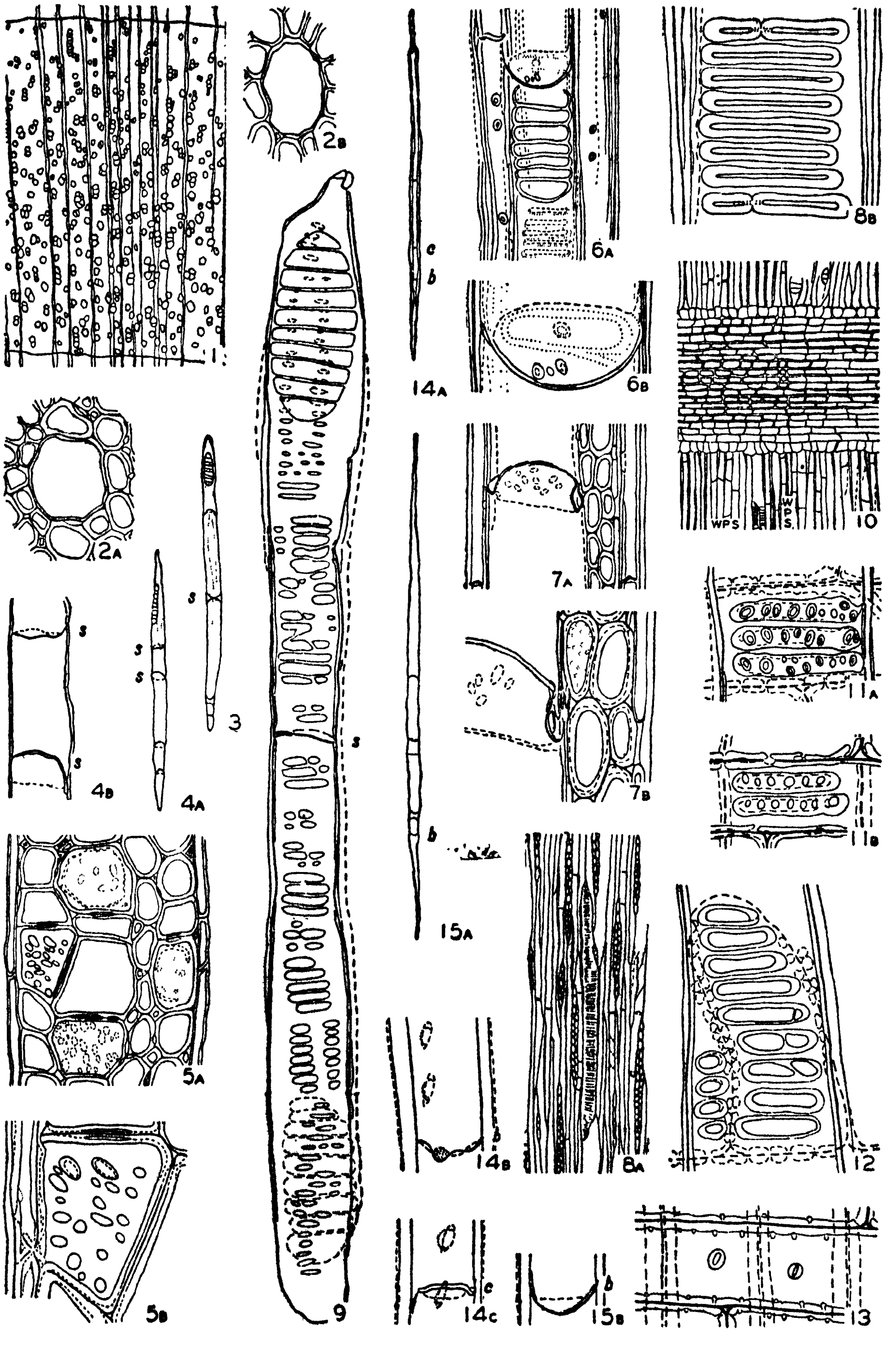
Fig. 13. R.L.S. X 426, Two adjacent cross-fields showing the pitting between the procumbent ray cell and two septate fibre-tracheids in the early wood.

Fig. 14a. M.M. X 38, A complete septate fibre-tracheid showing its outline and the occurrence of septa.

Fig. 14b. & c. Ibid. X 426, Portions of the cell showing the pitted and unpitted septa respectively. Note also the bordered pits onto the cell wall.

Fig. 15a. M.M. X 38, Another complete septate fibre-tracheid showing its outline and the occurrence of septa.

Fig. 15b. Ibid. X 426, A portion of the cell showing the unpitted septum only.


1
2B
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9
14A
15A
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A PRELIMINARY NOTE ON THE EFFECT OF DAY-LENGTH UPON THE DEVELOPMENT OF WHEAT

CHEN-CHUNG KING

Four varieties of wheat were used in this experiment. The seeds were sown in clay pots filled with garden soil. Every pot received 8 grains at first, then after 2 weeks of growth 4 plants out of the 8 were left to grow. The four varieties of wheat were: two spring types, Lee-Jen No. 4 and 9H178, and two winter types, Chung-Noon 28 and King-Tah 4197. Each variety was subjected to three different light conditions: the first one, grown under the natural day-length as control; the second, under the short day condition by curtailing the natural day-length to 8 hours, and the third, under the continuous illuminated long day condition with lighted 100 W electric bulbs for 16 hours in addition to the short day treatment. It was found that the tillering process was more vigorous under the short day condition than that under the long day condition. On the contrary, the length of the leaf blades under the short day treatment was less than that under the long day condition (Fig. 1). Furthermore, plants grown under the long day condition were come into ear earlier than that of the control by 20, 13, 7 and 9 days in the order of Lee-Jen No. 4, 9H178, Chung-Noon 28, and King-Tah 4197; while under the short day condition they failed to form any culms and ears. Only the early spring variety Lee-Jen No. 4 showed some culms at the end of the experiment.

Fig. 1. Development of wheat plants on the 50-th day after germination. (1, 2), (3, 4), (5, 6), and (7, 8) represent Lee-Jen No. 4, 9H178, Chung-Noon 28, and King-Tah 4197 respectively. Odd number: under the long day condition, even number: under the short day condition.

ADDITIONAL NOTES ON THE MEDICINAL PLANTS FROM SZECHWAN

TAI-YIEN CHEO

In my previous paper,* *"Medicinal Plants of Omei-Shan,"* I have enumerated 207 species of local drugs used by the natives. This paper reports on 95 species of additional medicinal plants from the localities of *Erh-O-Shan, Fan-Tien-Tzu, Sha-Ping, Mao-Ping,* and along a part of *Ta-Tu-Ho* or *T'ung River* in O-Pien Hsien. This investigation was financed by the National College of Pharmacy and the collection trip was made by me and Mr. *K. C. Hsu* in the late summer of 1938. In this trip it was revealed that most of the plants collected were not found in the *Omei-Shan* proper. All specimens cited here are recently identified and are now preserved in our herbarium. The medicinal uses and properties of these plants based upon the statements of some competent native herbalists, are reported here without any comment. These plants are arranged in their systematic order, and each plant is recorded in the following manner: (1) the botanical name; (2) the vernacular name as the herbalists used it, given in parenthesis; (3) the field number; (4) a brief statement of the habitat; and (5) the method of preparation and the complaint for which it is used. I give my thanks to Dr. *R. H. Shan,* Mr. *Y. W. Law,* and Mr. *N. T. Wang* for their help in the identification of Umbelliferae, Gymnosperms, and some Pteridophytes, respectively; and also to Mr. *K. C. Hsu* for his co-operation in the collection of the specimens.

HOMALIO-DENDRON sp. (Ch'ing-mu-mao-ying)—No. *782,* creeping on rock. Crush the whole plant and the poultice is used for boils.

EQUISETUM RAMOSISSIMUM Desf. (Chieh-chieh-ts'ao)—No. *667,* in moist place. The rhizome is soaked in wine for extract, used as a vulnerary.

SELAGINELLA MOELLENDORFFII Hier. (Shih-ling-chih)—No. *712,* on rock surface. Pound the whole plant with wheat flour into a paste; spread the paste over the wound caused by fire or boiling water.

PSILOTUM NUDUM Beauv. (T'ieh-sao-pa)—No. *619,* on old tree. Soak the whole plant in wine for extract, used as a remedy for trauma.

CIBOTIUM BAROMETZ (L.) J. Sm. (Ch'ing-mao-kou)—No. *620,* on cliff. The golden hairs from rhizome are used to stop bleeding by knife cuts.

BLECHNUM EBURNEUM Christ (Yen-keng-ts'ao)—No. *829,* on rock. Soak the whole plant in wine for extract, used as a vulnerary for mechanical injury.

CYRTOMIUM FRAXINELLUM Christ (T'ieh-tsui-kê)—No. *802,* on rock. Its medicinal properties and preparation are the same as for the above species.

DRYOPTERIS RAMPANS (Bak.) C. Chr. (Ma-nieh-chi)—No. *750,* on ditch bank. Pound the rhizome and the poultice is used for abscess.

*Published in Bot. Bull. Academia Sinica, 1:298-308, 1947.

LEMMAPHYLLUM DRYMOGLOSSOIDES (Bak.) Ching (Shih-chih-lan)—No. *760*, on rock surface. The whole plant is soaked in wine for a few weeks, then drink the extract day by day for curing lumbago or other sores of the body.

MICROSORIUM SUPERFICIALE (Bl.) Ching (Shu-yeh-tzu)—No. *759*, on tree. Spores are used in the treatment of snake-bite.

ONYCHIUM JAPONICUM (Thbg.) Kunze. (T'sui-lien-tzu)—No. *816*, on rock. Its medicinal use is the same as the above species.

PYRROSIA CALVATA (Bak.) Ching (Pa-yeh-i-chih-chien)—No. *814*, attached on rock surface. The whole plant is used as a vulnerary for mechanical injury.

PYRROSIA PETIOLATA (Christ) Ching (Shih-chien-hung)—No. *648*, on rock surface. Cut the whole plant into segments, then soak in wine for several weeks, and drink the extract day by day as a remedy for lumbago.

GINKGO BILOBA Linn. (Yin-hsin)—No. *803*, cultivated on slope. The edible seeds are used as a medicine for kidney disorders.

PIPER AURANTIACUM Wall. (Yen-yeh-feng)—No. *799*, climbing on rock. Simmer the whole plant in water and bathe in the decoction to cure swellings and sores.

ALNUS CREMASTOGYNE Burk. (Ch'ing-mu-shu)—No. *735*, on slope. The baked leaves are simmered in water for decoction, used as a diaphoretic.

BROUSSONETIA PAPYRIFERA (L.) Vent. (Shui-sang-tzu)—No. *722*, cliff face. The leaves are used as a diaphoretic.

FICUS FOVEOLATA Wall. (Shih-pao-ts'ao)—No. *771*, creeping on rock. Pound the leaves with flour to make a plaster, used to cure blisters on the skin of the children.

FICUS TIKOUA Bureau (Ti-kua-ken)—No. *738*, climbing on slope. Simmer the plant in water and drink the decoction to promote perspiration or to cast off phlegm.

HUMULUS JAPONICUS Sieb. et Zucc. (Ho-chuang-ts'ao)—No. *831*, along the bank of a stream. Crush the vegetative parts and use the poultice over malignant sores.

ELATOSTEMA sp. (Yen-pai-tzu)—No. *694* et *695*, rock side. Crush the whole plant and apply the poultice over the part injured by fire or boiling water.

LORANTHUS PARASITICUS (L.) Merr. (Ch'ing-kou-teng-chi-sheng)—No. *691*, parasitic on "Ch'ing-kou-teng". Pound the whole plant, steam with jujube, taken as a medicine for liver disorders.

VISCUM ARTICULATUM Burm. f. (T'ung-shu-chih-sheng)—No. *789*, parasitic on T'ung-oil tree. The plant is cut into short segments, cook with jujube, taken as a tonic for general weakness and liver complaint.

MOLLUGO STRICTA Linn. (Su-mi-ts'ao)—No. *774*, on gentle slope. Crush the whole plant with flour and boil in water for soup, taken to promote appetite.

TALINUM CRASSIFOLIUM Willd. (Tung-yang-ts'an)—No. *619*, cultivated in farm yard. Root is used as a tonic for general weakness.

ASTEROPYRUM PELTATUM D. et H. (Ti-hwang-lien)—No. *727*, on grassy slope. Pound the whole plant with vinegar and the poultice is used as an antiseptic for malignant sores.

CLEMATIS GRATA Wall. (Shan-chu-hua)—No. *675*, on hillock. Leaves are used as tea to relieve venomous diseases.

LIMACEA SAGITTATA Oliv. (Ta-yeh-ti-k'u-tan)—No. *724*, climbing on rock. The root is ground with gin, then the paste is taken to reduce abdominal sore, heart sore, and any kind of heart complaint.

ACTINODAPHNE CUPULARIS (Hemsl.) Gamble (Yieh-chen-nan)—No. *747*, on rocky slope. Soak the bruised leaves in boiling water for infusion, used as a remedy for trauma.

CINNAMOMUM WILSONI Gamble (Chuen-kwei)—No. *798*, among rocks. Bark is used as an aromatic condiment and appetizer.

LINDERA cf. CAUDATA Benth. (Shan-wu-tzu, Ta-tieh-hua-tzu)—No. *740* et *752*, on rock. Simmer the leaves in water and drink the decoction to relieve pain caused by mechanical injury.

ITEA CHINENSIS Hook. et Arn. (Ch'ing-tsui-tzu)—No. *808*, on brushy slope. The fruit is simmered in water, the decoction is taken as a stomachic for digestion.

PARNASSIA FABERI Oliv. (Yen-pao-tzu-hua). No. *783*, on shaded rock. Crush the whole plant, use the poultice for dog-bite.

ERIOBOTRYA JAPONICA Lindl. (P'i-p'a)—No. *734*, on slope. Fruit edible; young leaves are baked and simmered in water for decoction, used as a diaphoretic.

PRUNUS PADUS Linn. ? (Yen-pao-ke-tsao)—No. *765*, on ditch bank. Crush the leaves with flour and boil in water for soup, used as a stomachic. This specimen has subentire leaves.

BAUHINIA ALTEFISSA Levl. (P'o-p'o-teng)—No. *651*, twining on tree. Soak the root and stem in wine for extract, used as a vulnerary.

CAMPYLOTROPIS TRIGONOCLADA (Fr.) Schindl. (Shan-ts'ao-ts'an)—No. *658*, on bushy slope. Simmer the whole plant in water for decoction, used as a tonic for general weakness.

FLEMINGIA MACROPHYLLA (Willd.) O. Ktze. (Ch'a-yeh-ch'ing)—No. *706*, on bushy slope. Boil the whole plant in water, use the decoction to bathe swellings and sores.

LESPEDEZA SERICEA Miq. (Wa-tzu-ts'ao)—No. *655*, on slope. The whole plant is simmered in water for decoction, used as a stomachic.

MAACKIA CHINENSIS Takeda. (Kou-er-teng)—No. *702*, roadside. Cut the whole plant into segments, simmer in water, and bathe in the decoction to relieve pain caused by swellings and sores.

MILLETTIA PACHYCARPA Benth. (K'u-tan-tzu)—No. *726*, on rocky slope. The fruit is used as a fish poison.

ZANTHOXYLUM STENOPHYLLUM Hemsl. (Ch'ou-nan-chiao)—No. *770*, on hillock. Simmer the fruit in water and use the decoction as an antiseptic to wash swellings and sores. This specimen from Erh-O-Shan may possibly constitute a well-marked variety in having leaflets 3-5, rachis without prickles, and recurved short beaked fruits mostly in pairs.

MELIA AZEDARACH Linn. (Chuen-lien-shu)—No. *663*, on slope. The fruit has medicinal uses, the way of its use is not yet clear.

EUPHORBIA HUMIFUSA Willd. (P'a-wan-tzu)—No. *778*, on grassy slope. Soak the whole plant in wine for extract, rub the extract against the injured part of bone joints.

SABIA GRACILIS Hemsl. (Yen-ch'a-tiao)—No. *736*, among rocks. Soak the leaves in the boiling water, drink infusion as an expectorant.

HOVENIA DULCIS Thunb. (Kuao-tsao)—No. *687*, among thickets. Matured peduncle, sweet in taste, edible. Seeds are used to relieve intoxication from wine.

PARTHENOCISSUS THOMSONII (M. A. Laws) Planch. (Hung-wu-ch'ieh)—No. *717*, climbing on cliff. Pound the whole plant into a poultice, used for boils and sores.

HIBISCUS MANIHOT Linn. (Lei-lung-hua)—No. *666*, on slope. Smash leaves and root into a plaster, use the poultice for boils and sores.

HIBISCUS SYRIACUS Linn. (Mu-ching-hua)—No. *739*, on roadside. Cook the flowers with pork, take as a cure for leucorrhea.

EURYA ACUMINATA DC. (Ta-yeh-ch'iao-mi-tiao)—No. *794*, on slope. The leaves and fruits are used as a stomachic to promote digestion.

STACHYURUS HIMALAICUS H. f. et T. (T'ung-ts'ao-hua)—No. *746*, ditch bank. The pith is used as a diuretic.

ALANGIUM FABERI Oliv. (Niu-yeh-sang)—No. *739*, on rocky slope. The leaves are soaked in boiling water for infusion, used as a remedy to cast off phlegm.

ACANTHOPANAX SETCHUENENSIS Harms. (Shu-wu-chia)—No. *661*, on bushy slope. After mixing the bruised fruit with flour, boil the mixture in water and drink the soup as an appetizer.

PEUCEDANUM DECURSIVUM (Miq.) Maxim. (Ching-tang-kuei)—No. *779*, on gentle slope. The root is used as an emmenagogue.

SANICULA COERULESCENS Franch. (San-hsueh-ch'ing)—No. *784*, on rock. Crush the whole plant into a plaster, used as an antiseptic for malignant sores.

MAESA HUPEHENSIS Rehd. (Pai-chiao-tzu)—No. *772*, on cliff. Simmer the fruit in water, take the decoction to promote perspiration.

LYSIMACHIA FARGESII Franch. (Lo-rou-hwang)—No. *764*, on ditch bank. Crush the whole plant and use the poultice on the swollen and painful part.

FRAXINUS CHINENSIS Roxb. (Pai-la-shu)—No. *835*, cultivated on field margin. Carbonize the fruit and simmer in water for decoction, used as a stomachic.

LIGUSTRUM ACUTISSIMUM Koehne. (Shui-pai-la)—No. *754*, on rocky slope. Carbonize the leaves and boil in water for decoction, used as a refrigerant and for heart trouble.

LIGUSTRUM LUCIDUM Ait. (Pao-ke-tsao)—No. *688*, on slope. Simmer the bark and leaves in water, drink the decoction to promote perspiration.

CUSCUTA JAPONICA Choisy (Ti'en-peng-ts'ao)—No. *631*, parasitic on a tree. Soak the plant in wine, drink the extract as a vulnerary for mechanical injury.

VERBENA OFFICINALIS Linn. (T'ieh-ma-pien)—No. *638*, on slope. Simmer the whole plant in water for decoction, used to subside body temperature.

AGASTACHE RUGOSA (Fisch. et Mey.) O. Ktze. (Huo-hsiang)—No. *742*, cultivated. Simmer the whole plant in water; drink the decoction to cast off phlegm.

SIPHOCRANION NUDIPES (Hemsl.) Kuds. (Fang-fang-teng)—No. *768*, at foot of cliff. Crush the vegetative parts and use the poultice for malignant sores.

DATURA ALBA Nees. (Feng-ch'ieh)—No. *662*, on slope. Simmer the whole plant in water and bathe in the decoction in the treatment of rheumatism.

CHIRITA aff. PUMILA Don. (Pai-chi-hua)—No. *756*, rock side. Boil the whole plant in water and bathe in the decoction to relieve swellings and sores.

LOXOSTIGMA GRIFFITHII Clarke ? (Mao-yeh-hua)—No. *692*, on ditch bank. Simmer the whole plant in water and bathe in the decoction in the treatment of venereal disease.

BARLERIA CRISTATA Linn. (Ti-ting-ts'ao)—No. *630*, on slope. Pound the whole plant into a plaster, used as a poultice for malignant sores.

RUELLIA REPENS Linn. (Hsien-nan-hua)—No. *647*, on slope. Mix the bruised plant with egg, after frying, it is taken to cure cough.

MORINDA BRACTEATA Roxb. (Fang-king-shuh)—No. *714*, on rock. Soak the whole plant in wine, drink the extract to relieve bone-ache.

RUBIA CHINENSIS Regel et Maack. (Ssu-hsien-teng)—No. *622*, on gentle slope. Soak the whole plant in wine for a few weeks; drink the extract day by day to cure lumbago or other sores of the body.

CUCURBITA MAXIMA Duch. (Nan-kua)—No. *810*, cultivated in farm yard. The fruit is edible; the root is cooked with pork, taken to cure swellings and sores of the foot.

GYNOSTEMMA PEDATUM Blume (Wu-ching-teng)—No. *767*, on ditch bank. Simmer the whole plant in water, use the decoction as a gargle to kill tooth-germs.

THLADIANTHA CALCARATA Clarke (Yeh-shao-kua)—No. *737*, on hillock. Use the fresh root to rub the swellings and sores of the body.

ARTEMISIA JAPONICA Thunb. (Mai-t'ou-ts'ao)—No. *643*, on slope. Boil in water, drink as a refrigerant.

BIDENS TRIPARTITA Linn. (Shan-t'ou-cha-ts'ai)—No. *753*, on slope. The plant is simmered in water for decoction, used as a refrigerant and a cure for heart ailments.

CARPESIUM CERNUUM Linn. (Pi-hsi-ts'ao)—No. *792*, on grassy slope. Put the bruised leaves into nostrils to stop nose breeding.

ECLIPTA ALBA Hassk. (Li-ch'ang)—No. *775*, on rocky slope. Simmer the whole plant in water for decoction, used as an appetizer.

SAGITTARIA SAGITTIFOLIA Linn. (Yen-tz'u-kua)—No. *828*, in moist field. Pound the whole plant and use the poultice for malignant sores.

POTHOS SCADENS Linn. (Hsi-hwang-ts'ao)—No. *781*, on rock. The whole plant is used as a crude drug, the way of use is not clear.

COMMELINA COMMUNIS Linn. (Chu-yeh-hua)—No. *690*, on rock. Crush the whole plant and use the poultice for itchings and boils.

STREPTOLIRION VOLUBILE Edgew. (Ching-chu-yeh-hua, Hua-chu-yeh)—No. *719* et *720*, on fertile soil, under shade. Crush the vegetative parts into a plaster to paste on parts injured by fire or boiling water.

LIRIOPE GRAMINIFOLIA Baker (Pi-pao-tzu)—No. *780*, on rock. Crush the whole plant and use the poultice for causeless swellings and sores.

POLYGONATUM CIRRHIFOLIUM Wall. (Ta-yeh-hwang-ching)—No. *761*, on grassy slope. The rhizome is used as a tonic to increase energy and spirit.

REINECKIA CARNEA Kunth. (Chu-chieh-hua)—No. *677*, on hillock. The root is used as a vulnerary.

BLETILLA STRIATA (Thunb.) Reichb. f. (Shan-pai-chi)—No. *626*, on gentle slope, under shade. Cook the tuber with pork; take as a remedy for cough and also used as a tonic for lungs.

HABENARIA MIERSIANA Champ. (Pai-shen-ts'ao)—No. *635*, on grassy slope, under shade. Cook the root with pork; take as a remedy for colic.

OBSERVATIONS ON THE EMBRYOGENY OF PODOCARPUS NAGI

F. H. Wang

Buchholz (2, 3, 6) has reported in several papers the embryogeny of the Podocarpaceae, while the embryogeny of *Podocarpus Nagi* has been briefly described by Tahara (9). In this paper, the author considers the embryogeny of the same species of *Podocarpus* as studied by Tahara with special reference to those points which have been overlooked by the previous investigators.

Material for the present investigation was collected from several trees growing outside the morphological laboratory of the National Taiwan University during the summer of 1948 when the author was there a visitor in the Department of Botany. In the month of April, the female trees were bearing abundant ovules, well pollinated by the pollens from the male trees growing side by side. The following description was based upon the dissected embryo systems and supplemented occasionally by sections of the ovules. Buchholz' (4) method of preparation of dissected embryos was generally followed.

OBSERVATIONS

Proembryo Formation—The pollens of *Podocarpus Nagi* in Taipei began to shed on April 8, 1948; the shedding lasted for about a week. Fertilization was observed in the material collected in the middle of May, five weeks after pollination; it was two weeks earlier than that of the plant growing in Japan as reported by Tahara (9). The proembryo formation and the origin of binucleate embryonic cells have been described and illustrated by Tahara (9), therefore, at the present, it is unnecessary to include this portion of the description in this report.

Early Embryogeny—The embryonic initials remain binucleate until the prosuspensors have become considerably long and bended. Without exception, all species of the Podocarpaceae thus far reported (6, 7, 9) have binucleate embryonic cells.

Fig. 1 shows a sectioned embryo system in the early stage of development, the prosuspensors of which have begun to elongate while the binucleate embryonic cells still remain inactive. In the same figure, loosely attached rosette cells are shown above the prosuspensors. The number of embryonic cells, belonging to many ovules, was carefully counted; they are mostly within the range of 7-12 cells to one ovule (6, 9), though, in some rare cases, embryo systems with fewer embryonic initials have been observed. Three forms of embryonic cells may be distinguished, they are: the long cells, the short cells and the small cell or cells which are situated internally and completely surrounded by others (figs. 1 and 2). A typical form of the embryo system from a total mount of the dissected embryos is shown at two different foci in fig. 2a and 2b. Among the twelve embryonic cells there are three long cells, seven short ones and two small centrally situated cells.

The next step in the development is the formation of the multicellular embryos from the binucleate embryonic cells along with the further elongation and coiling of the prosuspensors. The development of all the embryos is not necessarily at the same

time. Fig. 3a shows five of the six embryonic cells forming multicellular embryos, while fig. 3b shows at a lower focus the other three embryonic cells of the same embryo system remaining binucleate. A more advanced stage is shown in fig. 4 in which there are nine multicellular embryos of almost the same stage growing together while the embryonal tubes are not yet formed.

The independent development of the embryos at the tips of the prosuspensors and the unequal growth of the prosuspensors result in the formation of a number of embryos from a single fertilized egg. It is evident that cleavage polyembryony is a regular occurrence in *Podocarpus Nagi*. This phenomenon was first noticed by Tahara (9) and further confirmed by Buchholz (6). Primary suspensors are absent. The massive embryonal tubes are well developed in a later stage (figs. 5 and 6). Fig. 5 shows four multicellular embryos with embryonal tubes, while fig. 6 shows eight embryos after cleavage and the one at the terminal position may contribute to the successful embryo of the mature seed.

The number of the embryo systems per ovule varies from 2 to 10. Table 1 shows the distribution of embryo systems in 64 ovules counted at random. The mean is 5.38±0.67 embryo systems per ovule with the standard deviation, 1.78.

TABLE 1. THE DISTRIBUTION OF THE NUMBER OF EMBRYO SYSTEMS PER OVULE IN *Podocarpus Nagi* (Count of 64 ovules)

No. of embryo systems	1	2	3	4	5	6	7	8	9	10	Total	Mean
Frequency	0	4	4	16	10	11	11	6	1	1	64	5.38 ± 0.67 $\sigma = 1.78$

σ=standard deviation

VARIATIONS IN EMBRYOGENY—Tahara (9), in his account of the embryogeny of *Podocarpus Nagi*, has probably overlooked the important fact that those embryo systems which go through the regular course of development are rather small in number since still more embryo systems in the same ovule do not follow the normal mode of development. Table 2 shows the result of a careful analysis of the normal and abnormal embryo systems in 21 ovules after the stage of cleavage. It is evident that less than one third of the total embryo systems follows the normal course of development. Generally only one or two, rarely three embryo systems give rise to the terminal normal embryos.

TABLE 2. THE DISTRIBUTION OF NORMAL AND ABNORMAL EMBRYO SYSTEMS IN *Podocarpus Nagi* (Analysis of 21 ovules)

No. of embryo systems		1	2	3	4	5	6	Total	Percentage
Normal embryo systems	Frequency	12	8	3					
	Total number	12	16	9				37	30%
Abnormal embryo systems	Frequency	2	2	7	3	7	2		
	Total number	2	4	21	12	35	12	86	70%

Embryo systems shown in figs. 5-9 were dissected out from a single ovule. There are five embryo systems developed from five fertilized eggs. Two of them (figs. 5 and 6) are normal in development while the other three (figs. 7, 8 and 9) form embryos in some peculiar ways. Fig. 7 shows numerous undifferentiated embryonic masses derived from the internal proliferation of the prosuspensors. In the same figure there is shown only a single terminal embryo with its embryonal tubes. The embryo systems shown in figs. 8 and 9 are similar in having their prosuspensor cells becoming embryonic and misshapen at the free ends. No normal embryo can be developed in this case. The prosuspensors, as a whole, may elongate considerably but no normal terminal embryos can be formed. The case shown in fig. 10 is found occasionally. Here the free ends of the prosuspensor cells become swollen and rounded. This type of prosuspensors is invariably without the terminal embryonic cells. It is not determined when this type of prosuspensor cells loses contact with their terminal embryonic cells or they are originally without embryonic cells at all. Individually detached prosuspensor cells may be found in many cases. The prosuspensor cells at any point of the cell may become embryonic. Fig. 12 shows the upper portion of the prosuspensors all the cells of which become embryonic but usually no terminal embryos can normally be developed. Sometimes one or several prosuspensor cells may become embryonic and detached to form misshapen embryos in various ways in an embryo complex. In such cases the terminal embryos may regularly develope. Fig. 13 shows the free end of an internally proliferated prosuspensor cell at a higher magnification. Prosuspensor cells which become embryonic are further shown in figs. 14 and 15. In fig. 14 three cells of the prosuspensor become embryonic and detached. Two of the three cells assume the pattern of irregular embryos and the third cells is of the same shape as that shown in fig. 13 but it is somewhat a little advanced in development since more cells are formed internally. Fig. 15 shows several multicellular embryos developed from an isolated prosuspensor cell.

Rosette embryos may be developed from the loosely arranged rosette cells. They usually orientate in different ways and sometimes numerous undifferentiated embryonic masses may be formed. Fig. 11 shows four rosette embryos in an advanced stage in development formed above the prosuspensors.

DISCUSSION

The competition in growth among the embryo systems in *Podocarpus Nagi* is rather keen since in each ovule more than five eggs are usually fertilized. As a result, more than two thirds of the embryo systems do not form the embryos in the normal course but they develope in various peculiar ways. This phenomenon has been observed by the present author in his material for the early embryogeny of *Glyptostrobus* (10). Though numerous misshapen embryos may be produced by means of internal proliferation of the prosuspensor cells and by the division of the rosette cells, probably they do not contribute to the successful embryo of the mature seed. The proliferation of the prosuspensor cells has been reported for *Cryptomeria* (1), *Taxodium* (8), *Cunninghamia* (5), *Glyptostrobus* (10) and several members of the Podocarpaceae (6). The present

finding in *Podocarpus Nagi* is comparatively a more extensive case. In this case it is doubtless that every cell of the embryonic group is a potential embryonic initial.

SUMMARY

The pollination of *Podocarpus Nagi* in Taipei, Formosa, takes place in the second week of April while the fertilization occurs in the middle of May.

In *Podocarpus Nagi* the number of embryo systems per ovule varies from 2 to 10. Only 30% of the total embryo systems follows the normal course of development.

Free internal proliferation of the prosuspensor cells and the development of the rosette embryos make all the cells in the embryonic group potential embryonic initials.

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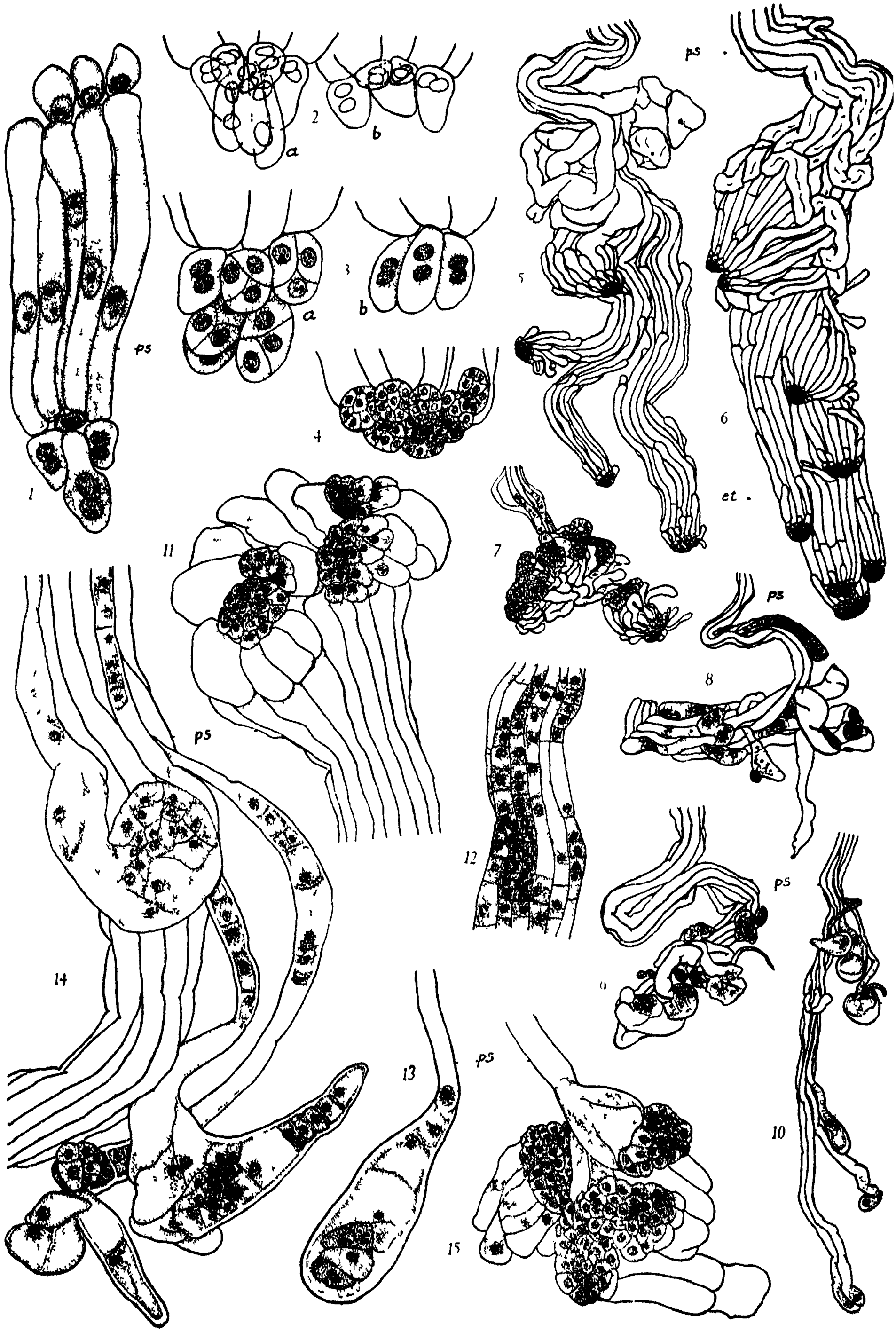
EXPLANATION OF FIGURES

Fig. 1-15. Embryogeny of *Podocarpus Nagi*. Description in text.—Fig. 1, x 280, May 24.—Fig. 2, 3, x 280, June 2.—Fig. 4, x 125, June 2.—Fig. 5, 6, 7, 8, 9, x 32, June 17.—Fig. 10, x 21, June 15.—Fig. 11, x 65, June 15.—Fig. 12, x 65, June 21.—Fig. 13, 14, x 65, June 15.—Fig. 15, x 65, June 11, 1948. ps, prosuspensor; et, embryonal tubes.


1
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2
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LEAF ANATOMY OF CHINESE SPECIES OF PODOCARPUS

CH'ANG-CH'IEN HO

The present paper represents the results of a study of the leaf anatomy of Chinese species of the genus *Podocarpus,* in an attempt to provide an aid in their species identification.

The first attempt to classify the species of *Podocarpus* on the basis of their leaf structure was made by Bertrand (2), who was followed by Mahlert (6), van Tieghem (8), and Bernard (1). As a result of their studies, it was established that it is possible to group different species of the genus together, according to the differences in their leaf structure. However, the results obtained by various authors had been rather inconsistent and it was not until the whole subject was reviewed and surveyed in considerable detail by Orr (7), that it has been established with certainty that "leaf anatomy does present some special features, which are peculiar to individual species, or to groups of allied species, and these, because of their stability, are of use as specific criteria, serving to distinguish the species possessing them from their congeners in the same or other geographical areas."

Subsequent to Orr's work, "A Taxonomic Revision of *Podocarpus*" was published by Buchholz and Gray (3), which covers American species of the genus and gives keys to all sections of the genus, on the basis of leaf anatomy alone. Most of the species remain to be identified by usual taxonomic methods.

MATERIAL AND METHODS

Altogether leaves of 22 herbarium mountings of *Podocarpus* were studied. These represent 3 different sections, 9 species and 1 variety, collected from 8 different provinces of China. The leaves were obtained through the kindness of Dr. W. F. Wang and Dr. R. H. Shan, to both of whom the author is deeply indebted. The list of the specimens follows: (p. 147).

Dry leaves were soaked and then boiled in distilled water for 5 to 15 minutes, until they sank to the bottom of the beaker upon cooling. They were then transferred to a mixture of equal parts of glycerine and 95% alcohol. Sections of leaves were obtained by the free-hand sectioning method and were subsequently transferred to glycerine-alcohol mixture or mounted in pure glycerine.

OBSERVATIONS

DIFFERENCE BETWEEN SECTIONS OF THE GENUS

Section *Dacrycarpus* is characterized by small, awl-shaped or scale-like leaves and does not present any identification difficulties, as already pointed out by Orr (7). Both *Nageia* and *Eupodocarpus* have large leaves, that are neither awl-shaped, nor scale-like.

Section	Species	Locality	Identified by
Dacrycarpus	*P. imbricata* Blume (ident. as *P. javanica* Merr.)	Kwangsi	R. C. Ching
Eupodocarpus	*P. costalis* Presl	Taiwan	Sasaki
	P. macrophylla D. Don	Chekiang	C. Y. Chiao
		Chekiang	C. Y. Yu
		Kiangsu	T. Y. Cheo
		Kwangtung	W. Y. Chun
		Szechuan	W. P. Fang
	P. macrophylla var. *Maki* Sieb.	Chekiang	C. Shen
		Kwangtung	McClure
	P. neriifolia D. Don	Kwangsi	R. C. Ching
		Kweichow	Y. Tsiang
	P. Nakaii Hay.	Taiwan	Kanehira
		Taiwan	Sasaki
	P. philippinensis Foxw.	Taiwan	Matsuda
Nageia	*P. formosensis* Dümm.	Taiwan	Sasaki
	P. Nagi Soll. et Mor.	Chekiang	R. C. Ching
		Chekiang	C. Y. Chiao
		Chekiang	Migo
		Taiwan	Fukuyama
		Taiwan	Sasaki
	(ident. as *P. nankoensis* Hay.)	Hainan	W. T. Tang
	P. Wallichiana Presl	Kwangtung	W. T. Tsang

Nageia is characterized by relatively broad leaves with many parallel veins, while *Eupodocarpus* is characterized by relatively narrow leaves, with a single median vein and well developed accessory transfusion tissue.

NAGEIA SPECIES

According to Florin (4) and Orr (7), section *Nageia* can be subdivided into 2 subsections, one with hypostomatous and another with amphistomatous leaves, which corresponds with the presence or absence of a receptacle in the female flower. While no amphistomatous leaves had been obtained, it appears possible to subdivide Chinese representatives of this section into two groups on the basis of the relative size of the resin canal, as compared with the size of the vascular bundle. *P. Wallichiana,* which according to Florin's classification, should be included within the amphistomatous group, possesses extremely well developed resin ducts, that are equal, if not larger in diameter than the vascular bundle itself. There is practically no rudimentary transfusion tissue (boie centripète of Bertrand,) while *P. formosensis* and *P. Nagi,* which are included in the hypostomatous group, have very small resin canals, when such are present, and

possess a strand of easily distinguishable rudimentary transfusion tissue (boie centripète) on each side of the vascular bundle. *P. formosensis* can be separated from *P. Nagi* by the manner of distribution of mesophyll fibers. In the former, they are always at a distance from the hypodermis, usually below the palisade tissue, while in the latter they frequently occur between the palisade cells and may be in immediate contact with the hypodermis. Mesophyll fibers are distinguishable by their greater diameter (25-50 μ), as compared to hypodermis fibers (10-20 μ). *Podocarpus nankoensis* Hayata, which Orr (7) tried to separate from the rest of the species of this subsection by the size of its mesophyll fibers, has been included into the species *P. Nagi* Soll. et Morr. by Kanehira (5), of which fact Orr (7) apparently had been unaware.

EUPODOCARPUS SPECIES

Section *Eupodocarpus* can be separated into two different groups by the character of the cuticle. There are species having smooth or nearly smooth cuticle on both surfaces of the leaf and, again, there are species possessing smooth or nearly smooth cuticle only on the upper surface of the leaf, while on the lower surface of the leaf the cuticle may be wavy or jagged in appearance.

Species possessing smooth or nearly smooth cuticle on both surfaces are: *P. Nakaii, P. neriifolia* and *P. philippinensis*. These can be further subdivided according to the type of hypodermis fibers. *P. philippinensis* is characterized by having two types of hypodermis fibers: smaller fibers, (10-18 μ in diameter) forming a continuous sheet in the immediate vicinity of the midvein area, and an interrupted layer of larger fibers (15-30 μ in diameter) in the leaf blade itself. Both *P. Nakaii* and *P. neriifolia* have a more or less homogeneous hypodermis, consisting of fibers 10-20 μ in diameter. *P. Nagaii* dffiers from *P. neriifolia* by the formation of isolated thick-walled parenchyma cells above and below the vascular bundle, while in *P. neriifolia* these cells are in a continuous mass, both above and below the vascular bundle.

Species possessing smooth cuticle on the upper surface of the leaf only are *P. costalis, P. macrophylla* and *P. macrophylla* var. *Maki*. *P. costalis* can be distinguished from the rest of the group by the appearance of the cuticle on the lower surface of the leaf, which is jagged, while in *P. macrophylla* species it is wavy. Moreover, there are no phloem fibers in *P. costalis,* the presence of which is typical for *P. macrophylla. P. macrophylla* can be distinguished from var. *Maki* by the character of mesophyll tissue above and below the vascular bundle. In *P. macrophylla* specimens this tissue has a more or less uniform appearance, while in var. *Maki* it is differentiated and consists, to a considerable extent, of thick-walled parenchyma cells.

KEY TO THE SPECIES

A. Leaves small, flat, on pectinate frondose twigs of limited growth .... (*Dacrycarpus*)..... *P. imbricata* Blume

AA. Leaves large

B. Vascular bundle single, median; midvein distinct; accessory transfusion tissue present .... (*Eupodocarpus*)

C. Cuticle smooth or nearly smooth on both leaf surfaces

D. Hypodermis of small fibers in midvein area, and larger fibers in the leaf blade; formation of large sclerotic fibers above xylem typical; phloem fibers present .... *P. philippinensis* Foxw.

DD. Hypodermis of more or less isodiametric fibers, formation of thick-walled parenchyma cells above and/or below vascular bundle typical; phloem fibers absent

E. Formation of isolated thick-walled parenchyma cells typical...... .... *P. Nakaii* Hayata

EE. Formation of thick-walled parenchymatous tissue typical.......... .... *P. neriifolia* D. Don

CC. Cuticle smooth on upper surface only

D. Cuticle jagged on lower surface; vascular sclereids present below vascular bundle; phloem fibers absent.......................... *P. costalis* Presl

DD. Cuticle wavy on lower surface; vascular sclereids absent; phloem fibers typically present

E. Mesophyll above and below vascular bundle not differentiated...... . ... *P. macrophylla* D. Don

EE. Mesophyll above and below vascular bundle with thick-walled parenchyma cells .... *P. macrophylla* var. *Maki* Sieb.

BB. Vascular bundles numerous; venation parallel; midvein absent; accessory transfusion tissue absent .... (*Nageia*)

C. Resin ducts well developed, equal to or larger in diameter than the vascular bundle itself; rudimentary transfusion tissue absent .... *P. Wallichiana* Presl

CC. Resin ducts small; rudimentary transfusion tissue present

D. Mesophyll fibers never adjacent to hypodermis, usually below palisade tissue .... *P. formosensis* Dümm.

DD. Mesophyll fibers frequently adjacent to hypodermis and occurring between palisade cells .... *P. Nagi* Pilg.

DISCUSSION

Leaf anatomy provides a convenient means for identification of representatives of the known species of *Podocarpus* in China. The method described is simple and can be applied when other means of identification fail. Results can be obtained within a reasonably short time (20-30 minutes). It appears worthwhile to extend the application of this method to other genera of the conifers. However, correctly determined herbarium specimens are necessary as starting material.

SUMMARY

A method for specific identification of Chinese species of *Podocarpus* is given and a key to all known species, based on leaf anatomy alone, is supplied. The method described has the advantage of rendering specific identification possible in the absence of reproductive organs.

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ANATOMY OF SIX CONIFEROUS WOODS OF SIKANG

C. H. Yu

The present paper contributes a knowledge of the anatomic features of some coniferous woods commonly found in the Sikang forests. Materials were collected by Prof. S. C. Teng during his investigation trips in Sikang. Altogether, four genera with six species are included.

Materials were prepared by softening the wood blocks in a mixture of equal parts of glycerine and ninety-five percent alcohol, to be cutted into sections with a sliding microtome. Staining is made with Haidenhain's iron-alum haematoxylin; safranin is used as a counterstain. Description of each species according to its anatomical features is given in detail. Brown and Panshin (1) and Phillips' (2) works are generally followed. A key for the identification of the species is also presented.

Abies Georgei Orr

Tracheids up to 40 μ in the tangential diameter, generally about 35 μ. Bordered pits on the radial walls of the spring-wood tracheids in one row; occasionally there are two bars to each pit membrane. Tangential pittings present in the last few rows of the summer-wood tracheids, small, numerous, and arranged in two irregular rows. In the first formed spring-wood tracheids tangential pittings also present. *Longitudinal parenchyma* is wanting. *Rays* of one type only, uniseriate, very variable in height, 1 to more than 20 cells high, consisting entirely of ray parenchyma. The horizontal walls of the ray cells strongly pitted, end walls nodular; containing gummy deposits near both ends. The cross-field pits predominantly taxodioid, but sometimes picioid; generally 1-2 in number in the spring-wood. *Resin ducts* wanting.

Pinus Armandi French.

Tracheids in the tangential diameter up to 45 μ, generally about 35 μ. Bordered pits on the radial walls of the spring-wood tracheids uniseriate, with slightly scalloped torus margins. Tangential walls of summer-wood tracheids pitted. *Longitudinal parenchyma* wanting. *Rays* of two types; (a) uniseriate rays numerous 1-14 cells in height, (b) fusiform rays scattered, with one horizontal resin duct, 2-seriate through the central portion. Ray tracheids regularly present in both types of rays, marginal and interspersed, non-dentate, one row on the upper and lower margins of the rays.

The horizontal walls of ray parenchymatous cells strongly pitted, end walls not nodular; indentures present. Pits in the cross-field 1-4, generally 1-2 in number, large, simple or nearly so in the spring-wood. *Resin ducts* of two types, vertical and horizontal, both with thin-walled epithelium; sometimes occluded with tylosoids.

PINUS YUNNANENSIS French.

Tracheids up to 35 μ in the tangential diameter, generally 20-30 μ. Bordered pits on the radial walls of the spring-wood tracheids in one row and very occasionally paired laterally. Tangential pitting wanting. *Longitudinal parenchyma* wanting. *Rays* of two types; (a) uniseriate rays numerous, up to 20 cells high, but generally less than 15 cells in height, (b) fusiform rays scattered, with one horizontal resin duct. Ray tracheids regularly present in both types of rays, dentate, marginal and interspersed, 1-4 frequently 1 or 2 rows on the upper and lower sides of the rays; some 1-3 cells high rays consisting entirely of the ray tracheids. The horizontal walls of ray parenchymatous cells pitted, end walls not nodular, indentures inconspicuous. Pits in the cross field of spring-wood 1-2, mostly 1 in number, large and simple or nearly so. *Resin ducts* of two types, vertical and horizontal, all with the thin-walled epithelium, and sometimes occluded with the tylosoids.

The anatomical features of the wood of this species are quite similar to those of *P. tabulaeformis* (3) except the former has the pitted horizontal walls of the ray parenchyma.

LARIX POTANINII Batal.

Tracheids up to 42 μ in the tangential diameter, generally 30-35 μ; without spiral thickening, with extremely thick-walled summer-wood tracheids. Bordered pits on the radial walls of the spring-wood tracheids in one row, evenly and closely distributed through the tracheids. Tangential pitting present in the last few rows of the summer-wood tracheids. *Longitudinal parenchyma* wanting. *Rays* of two types; (a) uniseriate rays numerous, 1 to more than 30 cells in height, generally 3-5 cells or 15-20 cells high, (b) fusiform rays scattered, with one horizontal resin duct, 2-seriate through the central thickened portion. Ray tracheids regularly present in both types of rays, non-dentate, marginal and sometimes interspersed. The marginal ray tracheids usually 1-3, sometimes 4 rows on both upper and lower sides; the outmost horizontal walls frequently wavy. The parenchymatous ray cells containing resinous deposits, horizontal walls strongly pitted, end walls nodular, indentures present. The cross-field pits picioid, small, 4-6, mostly 4 in 2 horizontal rows in the spring-wood. *Resin ducts* both vertical and horizontal present, epithelium of both types of ducts thick-walled; devoid of tylosoids. The number of the epithelial cells of the horizontal ducts is 6-9, and mostly 9.

The anatomical features of the wood of this genus are quite closely related to those of the genus *Picea;* but the dense, well-defined summer-wood bands and coloured heartwood of *Larix* are the best features for separating it from *Picea.*

PICEA LIKIANGENSIS Pritz.

Tracheids up to 36 μ in tangential diameter, generally about 30 μ; spiral thickenings present in the first formed spring-wood tracheids (sample was taken from a 83 years old tree). Bordered pits in one very rarely two rows on the radial walls of spring-wood tracheids. Tangential pitting present in the last few rows of the summer-wood tracheids and the first few rows of the spring-wood tracheids, small and relatively

numerous, arranged in one irregular longitudinal row. Resinous tracheids present. *Longitudinal parenchyma* wanting. *Rays* of two types; (a) uniseriate rays numerous, variable in height, 1 to more than 25 cells high, (b) fusiform rays scattered, with 1-2, rarely 2 horizontal resin ducts; 2-3, rarely 4-seriate through the central portion. Ray tracheids regularly present in both types of rays, marginal and interspersed; dentate, usually 1 or 2-3 rows on the upper and lower sides of the rays. The horizontal walls of ray parenchymatous cells strongly pitted, end walls nodular, with resinous deposits. Pits in the cross-field picioid, 2-4 in number, frequently 3 in a triangle form in the spring-wood. *Resin ducts* of two types, vertical and horizontal; both with thick-walled epithelium, occasionally containing tylosoids. The vertical ducts solitary or 2-3 in a tangential row, usually located in or near the summer-wood portion. The horizontal ducts with 6-9, generally 9 epithelial cells.

PICEA BRACHYTYLA Pritz.

Tracheids up to 40 μ in the tangential diameter, generally about 30 μ. Bordered pits on the radial walls of the spring-wood tracheids in one row. Tangential pitting present in the last few rows of summer-wood tracheids. *Longitudinal parenchyma* wanting. *Rays* of two types; (a) uniseriate rays numerous, up to 25 cells high, very occasionally with paired cells, (b) fusiform rays scattered with one, rarely two horizontal resin ducts; 2-seriate through the central portion. Ray tracheids regularly present in both types of rays, non-dentate, marginal, not interspersed; one row on both upper and lower sides of the rays; some 1-3 cells high rays consisting entirely of ray tracheids. The horizontal walls of the ray parenchymatous cells strongly pitted, end walls nodular, containing resinous deposits. Pits in the cross-field of the spring-wood picioid, 2-6 in number, generally 2-4 in 1 or 2, usually 1 horizontal row. *Resin ducts* of two types; vertical and horizontal, both with the thick-walled epithelium and devoid of tylosoids. The vertical ducts very sporadic and solitary. The horizontal ducts usually with seven epithelial cells.

KEY TO SPECIES

1. Resin ducts wanting .... *Abies Georgei*
1. Resin ducts present 2
2. Epithelium thin-walled 3
2. Epithelium thick-walled 4
3. Ray tracheids non-dentate .... *Pinus Armandi*
3. Ray tracheids dentate .... *Pinus yunnanensis*
4. Summer-wood tracheids with extremely thick walls .... *Larix Potaninii*
4. Summer-wood tracheids with normally thick walls 5
5. Ray tracheids dentate .... *Picea likiangensis*
5. Ray tracheids non-dentate .... *Picea brachytyla*

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NOTES ON SOME CHINESE PLANTS YIELDING TEA-SUBSTITUTES

TAI-YIEN CHEO

Tea is by far the most popular caffeine beverage known for its stimulating and refreshing qualities. It is freely used by one-half of the population of the world. The habit of tea-drinking in China is well known, but the plant used as tea, or *"Cha"* in the Mandarin dialect is not restricted to the tea plant (*Camellia thea* Link) alone. There are numerous tea-substitutes used as tea or as an adulterant for tea in this country. Furthermore, Chinese people often make use of some local plants to substitute tea for the sake of economy. The present paper makes a brief mention of these tea-substitutes through the investigation of the writer and readings in the Chinese literature. The purpose of this paper is not a mere enumeration of the species, but it is hoped that this record will be of some help in the grading and identification of tea where the purity of this commodity is stressed. Those plants which are used as seasonings and scent for tea are also reported here. Analytical keys are given when there are more than two species included within a particular group.

CHLORANTHACEAE

CHLORANTHUS spicatus (Thunb.) Makino, Tokyo Bot. Mag. 16:180. 1902.

This species is cultivated for its ornamental purposes in China, especially in Fukien and Kwangtung. The fragrant flowers are used to scent tea, then the tea is called *"Chu-lan-cha"*. The plant is, however, named *"Kin-su-lan"*.

BETULACEAE

ALNUS CREMASTOGYNE Burk., Journ. Linn. Soc. 26:409. 1899.

This tree is very common in occurence along the Min River in Szechuan, but it does not occur east of the city of Suifu along the Yangtze River. In the Chengtu Plain it is planted by the side of the rice fields, streams and irrigation canals and is one of the principal sources of fuel.

This plant is popularly known as *"Kai-mu"*, and its young leaves, after air-drying, can be used as tea.

FAGACEAE

PASANIA POLYSTACHYA Oerst., Vidensk. Selsk. 5(9): 379. 1873.

The leaves of this plant are reported to be used in a famous tea, named *"T'ien-cha"* in the vicinity of Chin-yun-shan, Peip'ei, Szechuan. It is sold by the monks of the Chin-yun Temple. It gives a sweet taste which is much appreciated by the visitors to that region. The specimen of this plant was not seen.

SANTALACEAE

OSYRIS WIGHTIANA Wall., Cat. n. 4036; Wight, Icon. Pl. Ind. Orient. 5:17, t. 1853. 1852.

The leaves of this plant are used as tea by the native tribes in Opien; the tea is named *"Man-nu-cha"*. It is distributed from Szechuan to Kwangsi and Yunnan.

RANUNCULACEAE

CLEMATIS GRATA Wall., Cat. n. 4668; Hook. f., Fl. Brit. Ind. 1:3. 1872.

This species occurs in the Central and South-western China. Its leaves are used as a substitute for tea by the mountaineers in the Omei-shan, Szechuan. Its vernacular name is *"Shan-chu-hua"*.

It is first recorded by the writer and Mr. *K. C. Hsu* in their notes of collections (No. *675*).

LAURACEAE

LINDERA COMMUNIS Hemsl., Journ. Linn. Soc. 26:387. 1891.

The young leaves of this plant can be used as a substitute for tea; its branches and old leaves are used as one of the raw materials for making incense sticks.

It is first reported as a tea-substitute, known as *"Lao-jen-cha"* in the Omei-shan, according to the writer and Mr. *K. C. Hsu's* collection (No. *811*) in that region in the September of 1938. This plant is widely distributed in the southwestern provinces.

LITSEA HUPEHANA Hemsl., Ind. Fl. Sin. 2:382. 1891.

The leaves of this plant are reported to be used as tea, named *"Lao-yin-cha"*, in the vicinity of Chin-yun-shan, Peip'ei, Szechuan. The specimen of this plant was not seen. This species is originally recorded in Hupeh..

ROSACEAE

ROSA RUGOSA Thunb., Fl. Jap. 213. 1784.

This shrub is commonly cultivated in China for its ornamental purposes; it is named *"Mai-kwei-hua"*. Its dried flower buds and petals are sometimes used to scent tea and to spice cakes and candies.

LEGUMINOSAE

CASSIA MIMOSOIDES Linn., Sp. Pl. 379. 1753.

This plant occurs in the North China, and is locally called *"Shan-pien-tou"*. It is reported that its dried stems and leaves can be used as tea.

LESPEDEZA BICOLOR Turcz., Bull. Soc. Nat. Mosc. 13:69. 1840.

It is a common species in China, the dried young leaves are used as a substitute for tea, named *"Sui-chun-sha"*.

RUTACEAE

1. Fruit sour, not edible, rind orange red, tight; flowers very fragrant.... *Citrus aurantium* var. *amara.*
1. Fruit sweet, edible, rind red, loose; flowers fragrant.......................... *Citrus tangerina.*

CITRUS AURANTIUM Linn. var. *amara* Engl.

This plant is cultivated for its very fragrant flowers which are baked and mixed with tea to increase the flavor. It is widely used in Soochow and Hangchow. The tea is commonly called *"Tai-tai-hua cha"*.

CITRUS TANGERINA Hort. ex Tanaka in China Citr. Rep. 8. 1926.

This species is a native of India; it is now widely cultivated in Foochow and Changchow. It is the Chinese red orange, called *"Hung-chu"* or *"Foo-chu"*, the rind of which is used as a medicine or to scent tea and wine occasionally.

BURSERACEAE

CANARIUM ALBUM Raeusch., Nomc. Bot. ed. 3, 287. 1797.

This is the Chinese olive, named *"Kan-lan"*. It is a native of Hainan Island, widely cultivated in Fukien and Kwangtung. The fruit is edible either fresh or after various methods of preparation. It is customary to put one or two fresh pounded fruit into the tea, *"Kan-lan-cha"*, especially during the New Year days. It improves the flavor of the tea, and is also beneficial to the throat.

MELIACEAE

AGLAIA ODORATA Lour., Fl. Cochinch. 173. 1790.

This small tree is naturally distributed in the South China, cultivated in Kwangtung for its ornamental purposes. It is named *"Shu-lan"*, its fragrant flowers are used to scent tea.

CEDRELA SINENSIS, Juss., Mem. Mus. Par. 19:294. 1830.

It is widely distributed in the Central and North China, commonly cultivated in Hopei. Its vernacular name is *"Hsiang-chung"*.

The young shoots and leaves are edible, used as a substitute for tea in some districts. It is called *"Hsiang-chung-cha"*.

ANACARDIACEAE

PISTACIA CHINENSIS Bge., Mem. Sav. Etr. Acad. Sci. St. Petersb. 2:89 (Enum. Pl. Chin. Bor. 15). 1833.

This tree is widely distributed in China. Its vernacular name is *"Hwang-lien-mu"*. Both young shoots and leaves are edible in the spring as a potherb, then it is called *"Hwàng-lien-ya"*. It is also used as a substitute for tea by the peasants in Chekiang and Hopei, known as *"Hwang-er-cha, or Hwang-li-cha"*.

AQUIFOLIACEAE

1. Flowers solitary in the axils of leaves on young branchlets; leaves leathery, ovate to elliptic, about 8 cm. long and 3 cm. broad, margin appressedly serrate............. *Ilex purpurea* var. *Oldhami.*
1. Flowers fascicled in the axils of leaves on last year's branchlets............................ 2
2. Leaves leathery, narrowly elliptic to lanceolate-elliptic, about 9 cm. long and 3 cm. broad, margin sharply serrate only above the middle or near the apex. .... *Ilex Fargesii.*
2. Leaves thick and leathery, long elliptic to oblong elliptic, about 18 cm. long and 6.5 cm. broad, margin distantly serrate .... *Ilex latifolia.*

ILEX PURPUREA Hassk. var. OLDHAMI (Miq.) Loesn., Nov. Act. Leop.-Carol. 78:112. 1901.

This variety is distributed in the valleys of the Yangtze River, known as *"Tung-tsing"*. Its leaf-buds or young leaves are mixed with tea as an adulterant.

ILEX FARGESII Franch., Journ. de Bot. 12:255. 1898.

This plant is naturally distributed in Hopeh, Szechuan and Sikang. It is locally named *"King-yeh-cha"* in Opein, Szechuan. The writer and Mr. *K. C. Hsu* collected the specimens there in the September of 1938, and recorded in their field notes: "shrub, 5 ft. high, on slope; fruit reddish; leaves used as tea".

This species is closely related to *I. Franchetiana* Loes. which has broader elliptic leaves with serrate margin, while the former has narrower leaves with sharply serrate teeth only above the middle or near the apex. The leaf-buds or young leaves in having a sweet taste can be used as a substitute for tea.

ILEX LATIFOLIA Thunb., Fl. Jap. 79. 1784.

This tree occurs in Chekiang, Fukien and eastward to Japan. Its young leaves are used as an adulterant for tea in the Anhui province. As its leaves are very broad, it is named *"Ta-yeh-tung-tsing"* in Chinese.

CELASTRACEAE

EVONYMUS SUBSESSILIS Sprangue var. LATIFOLIA Loes., Sarg. Pl. Wils. 1;489. 1913.

The leaves of this variety are very similar to those of *E. Bockii* Loes., but their petioles are shorter and the capsules show a few small prickles, while those of *E. Bockii* are always quite smooth.

The young leaves of this plant are used as a substitute or as an adulterant for tea in the Omei-shan, Szechuan. Its vernacular name is *"Shu-cha-hua"*. It is first recorded by the writer and Mr. *K. C. Hsu* in their collection notes (No. *321*).

ACERACEAE

1. Leaves membranaceous, entire or 3-lobed, margin incisedly serrate . . . . *Acer ginnala.*
1. Leaves coriaceous, usually 5-lobed 2
2. Leaves truncate at base; wings of fruits about as long as nutlets . . . . *Acer truncatum.*
2. Leaves subcordate at base; wings of fruits about twice as long as nutlets. . *Acer pictum* var. *parviflorum.*

ACER GINNALA Maxim., Bull. Phys.-Math. Acad. Sci. St. Petersb., 15:126. 1857.

This species is widely distributed in the Central and North China, and it is commonly called *"Cha-tiao"*.

The young leaves of this plant after baking can be used as tea, named *"Shong-cha"*.

ACER TRUNCATUM Bge., Enum. Pl. Chin. Bor. 10. 1833.

It is a common wild species in the North China, and its vernacular name is *"Kua-tzu-cha"*.

The young shoots and leaves are edible, often used to adulterate the famous *"Lung-ching"* tea in Hopei. The seeds are also edible.

ACER PICTUM Thunb. var. PARVIFLORUM Schneid., Ill. Handb. 2:225. 1907.

This variety occurs in the Yangtze Valley and also in Honan, Hopei, Kansu, and Northeastern provinces. Its vernacular name is *"Chi-chao-tzu"*. Its young leaves are edible and used also as a substitute for tea.

SABIACEAE

SABIA GRACILIS Hemsl., Hook. Icon. 29, t. 2831. 1907.

This species is previously reported from Kweichow and Szechuan. The leaves of this plant are used in the vicinity of Erh-O-Shan as tea for relieving phlegm. The writer and Mr. *K. C. Hsu* (No. *736*) first noted it in 1938. Its vernacular name is *"Yen-cha-tiao"*.

RHAMNACEAE

1. Leaves ovate, 1-6 cm. long, 0.7-3.4 cm. broad, glaucous beneath............ *Berchemia racemosa.*
1. Leaves broadly ovate to elliptic, 4-10 cm. long, 2.5-6 cm. broad, golden beneath.................. .... *Berchemia hypochrysa.*

BERCHEMIA RACEMOSA Sieb. et Zucc., Abh. Akad. Munch. 4 (2):147 (Fl. Jap. Fam. Nat. 1:39). 1845.

The leaves of this plant can be used as a substitute or as an adulterant for tea. It is distributed in the South-western China, named *"Nu-er-cha"* in the Omei-shan (*Cheo* et *Hsu* No. *274*, Aug. 20, 1938), Szechuan. It occurs also in Taiwan and Japan.

BERCHEMIA HYPOCHRYSA Schn., Sargent, Pl. Wils. 2:214. 1914.

This plant occurs in Hupeh and Szechuan. Its vernacular name is *"Tien-cha"*. It has the same use as the above species.

RHAMNUS DAVURICUS Pallas, Reise Russ. Reich. 3, append. 721. 1776.

This species is distributed in Honan, Hopei, and North-eastern China.

The young shoots and leaves are edible, often used as a substitute for tea by the peasants at the Eastern-Tombs in Hopei. Its bark is used as a medicine and also as a dye-stuff.

MALVACEAE

HIBISCUS SYRIACUS Linn., Sp. Pl. 695. 1753.

This species is widely distributed in China. Its vernacular name is *"Mu-chien"*. Its young leaves can be used as a tea-substitute. Its flowers (white) are edible; the seeds and bark can be used as medicine.

STYRACACEAE

STYRAX SUBERIFOLIUS Hook. et Arn., Bot. Voy. Beechey, 196, t. 40. 1841.

This plant is naturally distributed in the Central and South China down to Taiwan. Its leaves are used as tea by the mountaineers of Omei-shan in Szechuan. (*Cheo* et *Hsu* No. *228*, Aug. 17, 1938.) Its vernacular name is *"Shan-pai-cha"*.

OLEACEAE

CHIONANTHUS RETUSUS Lindl. et Paxt., Paxton's Flow. Gard. 3:85. 1853. Fig. 273.

This tree is widely distributed in China and is known as *"Cha-yieh-shu"*. The leaf buds and the young leaves are used as tea, its flavor is by no means inferior to the famous Chinese tea, *"Lung-ching"*. The so called "Lung-ching" tea sold in Hopei is often of the leaves of this tree.

1. Leaves compound, 5-7 leaflets; corolla-lobes mucronate................*Jasminum grandiflorum.*
1. Leaves simple; corolla-lobes obtuse..*Jasminum Sambac.*

JASMINUM GRANDIFLORUM L., Sp. Pl. ed. 2, 9; DC. Prod. 3:313. 1844.

This shrub occurs in Yunnan down to India and An-nan. It is widely cultivated in Kwangtung for its flower-buds which are used to spice tea or wine, and also for the oil extract of the flowers used as a hair tonic. The vernacular name is *"Su-hsing-hua"*.

JASMINUM SAMBAC (L.) Ait., Hort. Kew, ed. 1. 1:8. 1789.

This evergreen vine is introduced into South China from India, and it is now commonly cultivated as an ornamental plant all over the country under the vernacular name *"Mo-li-hua"*. It is widely cultivated in Foochow for its flower-buds which are used to improve the flavor of tea.

1. Flowers lilac-purple to white, corolla-tube much longer than the calyx; stamens inserted above the middle of corolla-tube, anthers subsessile; leaves broadly ovate, truncate or subcordate at the base .... *Syringa oblata.*
1. Flowers yellowish-white, corolla-tube as long as the calyx; stamens long-exserted, anthers on slender filaments; leaves ovate to ovate-lanceolate, attenuate or narrowed at the base .....*Syringa pekinensis.*

SYRINGA OBLATA Lindl. ex Carr. in Fl. des Serres, 13:126. 1858.

The young leaves are used as a substitute for tea by the peasants in Hopei. This species occurs naturally in North China. Its vernacular name is *"Hua-pei-tzu-ting-hsiang"*.

SYRINGA PEKENENSIS Rupr., Bull. Phys.-Math. Acad. Petersb., 15:371. 1857.

The young leaves are edible and often used as a substitute for tea by the peasants of Hopei. This species occurs also in the other parts of North China. Its vernacular name is *"Peiping-ting-hsiang"*.

OSMANTHUS FRAGRANS Lour., Fl. Cochin. 28. 1790.

This species is a favorite ornamental tree on account of its very fragrant flowers and handsome foliage, so it is widely cultivated in the gardens and parks in China. The fragrant flowers, commonly called *"Kwei-hua"*, are often used to scent tea, candies, or cakes.

LABIATAE

BRUNELLA (PRUNELLA) VULGARIS Linn., Sp. Pl. 600. 1753.

It is a common weed widely distributed all over China. *"Hsia-ku-ts'ao"* is its vernacular name. Its dried and baked spikes are soaked in the boiling water, then the infusion is used by the peasants of some districts as a cold drink in the summer to take the place of tea.

MENTHA ARVENSIS Linn., Sp. Pl. 577. 1753.

This is a common cultivated herb of economic importance. It is popularly known as *"Po-ho"*. Soak the dried stems and leaves in the boiling water, then the infusion is used as a cold drink in the summer to take the place of tea, or as a medicine.

SCHIZONEPETA TENUIFOLIA Briq., Engl. et Pr. Nat. Pfl.-fam. 4 (3a):235. 1887-89.

This is also a cultivated plant and its vernacular name is *"Ching-chieh"*. The dried stems and leaves are soaked in the boiling water which is taken as a cold drink in the summer. The seeds are used as a medicine.

SOLANACEAE

LYCIUM CHINENSE Mill., DC. Prodr. 13(1):510. 1852.

This species is "commonly known in the English gardens as tea-tree, and is sometimes called Lord Macartney's tea". It is widely distributed in China, under the vernacular name *"Kou-chi"*. Its dried leaves can be used as a substitute for tea, and its fruit is used as a medicine.

RUBIACEAE

DIPLOSPORA VIRIDIFLORA DC., Prodr. 4:477. 1830.

This plant is named "Kou-ku-tzu"; it occurs in Fukien, Kwangtung, and Taiwan. Its fruit can be simmered in water and the decoction is taken as coffee.

GARDENIA RADICANS Thunb., Fl. Jap. 109, t. 20. 1784.

This low shrub is endemic in China and is commonly cultivated in the gardens for ornamental purposes. Its flowers can be used to scent tea. Its vernacular name is *"Ch'iao-she-hua"*.

CAPRIFOLIACEAE

LONICERA JAPONICA Thunb., Fl. Jap. 89. 1784.

This woody vine is valued for its handsome flowers appearing during the summer. Its flowers or stems and leaves after drying can be used as a substitute for tea and as a medicinal plant in this country. The vernacular name is *"Kin-yin-hua* or *Jen-tung"*. It is widely distributed and cultivated in China. It occurs also in Japan and Korea.

VIBURNUM ERUBESCENS Wall. var. PRATTII Rehd., Sargent, Pl. Wils. 1:107. 1911.

This variety is distinguished by its broadly obovate or elliptic or rarely oblong-obovate leaves, 5-14 cm. long and 3-7 cm. broad, with pubescence persistent at least on the veins and in the axils of veins.

The young leaves of this plant are used as tea by the mountaineers of Omei-shan, and are commonly called *"Tien-cha", the specimens* of which were collected by the writer and Mr. *K. C. Hsu* (No. *318,* Aug. 24, 1938) in Szechuan.

COMPOSITAE

CHRYSANTHEMUM MORIFOLIUM Ramat., Journ. Nat. Hist. 2:240. 1792.

The flower heads of this cultivated chrysanthemum are reported as an export from Chekiang and taken as an infusion for its cooling effect during the summer. It is reported that this species is the native *"Peh-chu-hua"*, but there is no specimen from the field where they are grown for use as a tea-substitute.

GRAMINAE

HORDEUM VULGARE Linn., Sp. Pl. 84. 1753.

This is barley which is cultivated as a field crop under the vernacular name of *"Ta-mai"* in China. The slightly carbonized grains are soaked in boiling water for a

drink during the summer time. It is usually used by the peasants in Kiangsu for its cooling and peptic effects. The germinated barley is used medicinally.

PHRAMITES COMMUNIS Trin., Fund. Agrost. 134. 1820.

This reed is common in China, known as "*Lu* or *Lu-wei*". The root, "*Lu-ken*", is regarded as a cooling and diuretic agent. It is used as a substitute for tea, and has a sweetish taste. The tender sprouts are slightly bitter and are used as a food or as a medicine.

PHYLLOSTACHYS spp.

The leaf sprouts of bamboo under the vernacular name of "*Chu-hsin*", are sometimes regarded as a substitute for tea and as a cooling and diuretic agent.

THE FOREST TREES OF NORTHEASTERN CHINA, I.

CHIEN P'EI

Since reforestation in China is being carried out throughout the country, a manual for the forest trees is an urgently needed reference to the foresters. This paper is aimed at to meet this purpose. The forest trees of Northeastern China is selected as the first installment of the author to begin a series of articles on forest trees. The material for this paper is based upon Mr. C. K. Chow's collection during his stay in Northeastern China in the year 1948-1949, in addition to the preserved specimens of the same locality in our herbarium. To facilitate the field workers on forestry, only the important features of each species and an analytical key to each genus are given in this paper.

GYMNOSPERMS

Usually evergreen tall trees, rarely low shrubs, with leaves needle-shaped, scale-like or oblong-elliptic, rarely fan-shaped; flowers unisexual; ovules naked growing usually on scales.

PINACEAE

Evergreen, rarely deciduous, tall trees; leaves linear, linear-lanceolate, alternate or opposite or whorled; flowers unisexual, monoecious, cone-like; ♂ flowers consisting of many scales bearing 2-celled anthers on the underside; ♀ flowers with numerous spirally arranged scales; cone woody maturing in the second year, with distinct scales and bracts; seeds 2 on each scale, winged or wingless; cotyledon 4-15.

1. Leaves solitary 2
1. Leave in fascicles or clusters of 2 or more 3
2. Cone upright with deciduous cone-scales ....

2. Cone pendulous with persistent cone-scales .... *Picea*
3. Leaves many, clustered on short thick spurs; cone-scales flat at apex .... *Larix*
3. Leaves in fascicles of 2-5, sheath at base by scarious bud-scales; cone-scales usually much thickened at apex .... *Pinus*

Abies Miller

Evergreen pyramidal-shaped trees; branches whorled; bark smooth and thin while young, thick and furrowed on old trees; branchlets smooth or grooved in a few species; winter-buds resinous; leaves often 2-ranked, linear or linear-lanceolate, contracted above the base and leaving a circular scar as they fall, usually flattened and grooved above, mostly with 2 white stomatiferous bands below, without or rarely with stomata above, with 2 or rarely 4 resin ducts either internal or marginal; ♂ flowers pendent, oval to cylindric-oblong, with yellow or scarlet anthers; ♀ flowers ovoid to oblong, consisting of numerous 2-ovuled imbricate scales; cone ovoid to oblong-cylindric with closely imbricated thin and leathery scales incurved at apex, narrowed at base into a long stipe and subtended by narrow exserted or enclosed bracts; the scales falling at maturity from the persistent axis; seeds ovoid or oblong with large thin wing; cotyledons 4 to 10.

About 40 species in the temperate regions of the N. Hemisphere; we have two species in Northeastern China.

The following species are reported from the past by explorers in Manchuria. Mr. Chow has collected all these species. This region is not throughly explored, there may be more species to be discovered as intensive exploration takes place.

1. Branchlets glabrous; leaves acute at apex .... *A. holophylla.*
1. Branchlets pubescent; leaves emarginate at apex .... *A. nephrolepis.*

Abies holophylla Maxim., Bull. Acad. Sci. St. Petersb. 10: 487. 1866, Mél. Biol. 6: 11: 349. 1882-83. (Fig. 1: B and B')

Trees up to 30 m. high, winter buds slightly resinous; branchlets glabrous, slightly grooved, yellowish gray; leaves pectinate below, spreading above at nearly right angles outward and upward; 2-4 cm. long, acute at apex, obtusish or acute, spiny-pointed in young plants, lustrous bright green above, with 2 inconspicuous whitish bands beneath; resin-ducts internal; cone cylindric, about 14 cm. long, light brown at maturity; scales 3-5 cm. broad, entire; bracts hidden.

Sungkiang: *C. K. Chow 1054.*

Also in Korea.

Abies nephrolepis (Trautv.) Maxim., Bull. Acad. Sci. St. Petersb. 10: 486. 1866, Mél. Biol. 6: 21. 1866. (Fig. 1: A and A')

Abies sibirica Ledeb. var. nephrolepis Trautv., Maxim., Mem. Acad. Sci. St. Petersb. Sav. Etr. 9: 29 (Prim. Fl. Amur.). 1859.

Trees up to 30 m. high; bark of the trunk rough; branchlets more or less pubescent; leaves short, emarginate at apex, lustrous green above, with two conspicuous white bands beneath; cones smaller, about 8 cm. long; scales about 1 cm. long, with narrow bracts about 2/3 as long as the scales.

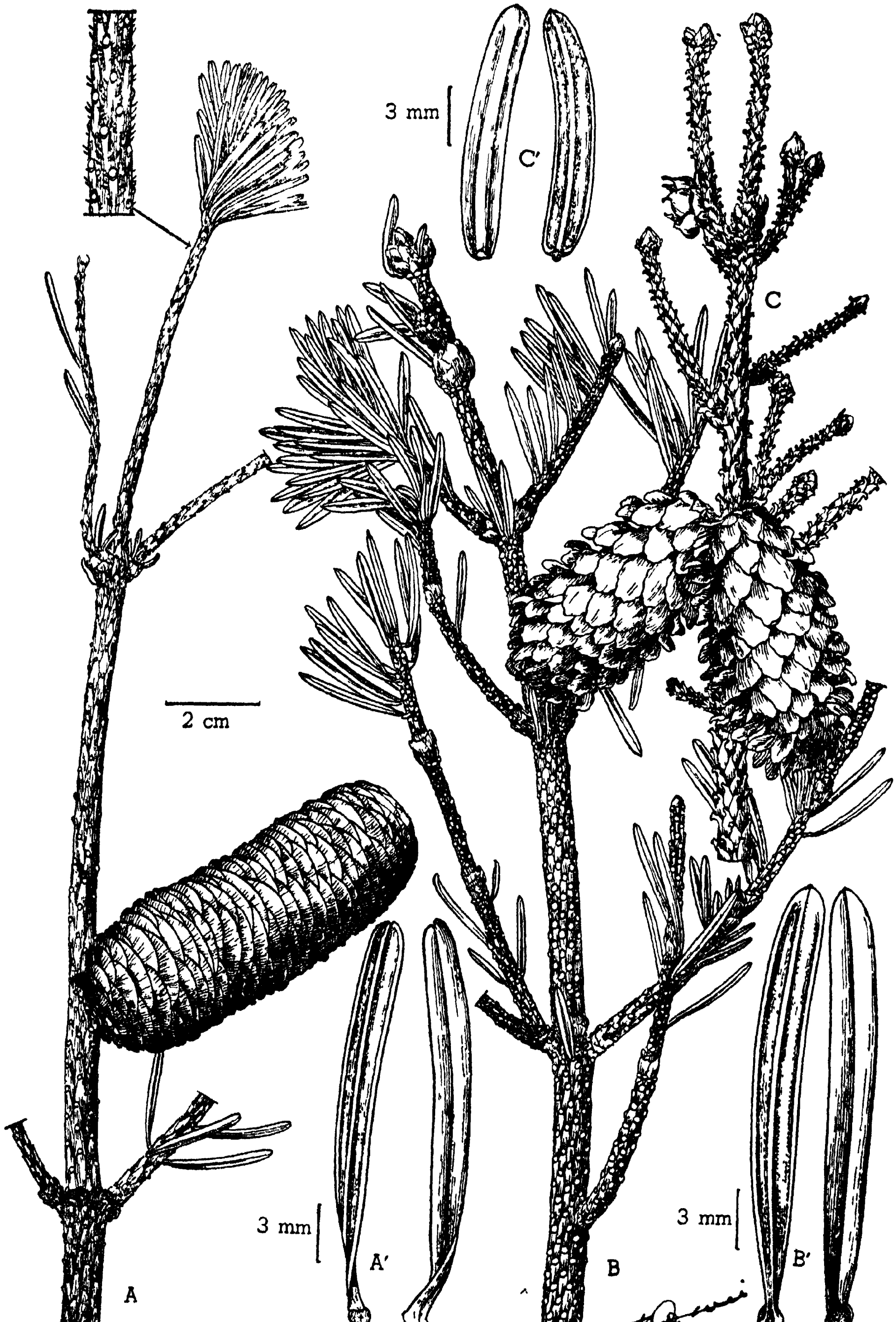

Fig. 1: A, A' Abies nephrolepis (Trautv.) Maxim., B, B' Abies holophylla Maxim., C, C' Picea jezoensis (Sieb. et Zucc.) Carr.

Sungkiang: *C. K. Chow 1041.*
Also distributed from E. Siberia to N. China.

PICEA A. Dietrich

Evergreen pyramidal trees with scaly bark and whorled branches; branchlets with prominent leaf-cushions (pulvini) separated by incised grooves and produced at apex into a peg-like stalk bearing the leaf; buds ovoid or conical, with or without resin; leaves spirally arranged, on the under side of the branchlets usually pectinate linear, usually 4-angled and stomatiferous on all 4 sides or compressed and stomatiferous only on the upper (ventral or inner) side which appears to be the lower one by a twisting of the leaves, with 2 marginal resin-ducts, rarely without; ♂ flowers axillary catkin-like, yellow or red, consisting of numerous spirally arranged anthers; ♀ flowers terminal, green or purple, consisting of numerous 2-ovuled bracted scales; fruit an ovoid to oblong-cylindric pendulous or sometimes spreading to nearly upright cone, with persistent, suborbicular to rhombic-oblong scales subtended by small bracts; seeds 2 under each scale, small, compressed, winged.

About 40 species in the cooler and temperate regions of the N. Hemisphere, from the arctic circle to the high mts. of the warm-temperate regions.

PICEA JEZOENSIS (Sieb. et Zucc.) Carr. Traite Conif. 255. 1855. (Fig. 1: C and C')
Abies jezoensis S. et Z. Fl. Jap. 2: 19, t. 11. 1842-'70.

Trees up to 50 m. high, with spreading slender branches; bark gray, scaly, deeply fissured on old trees; buds conical, lustrous, resinous; branchlets glabrous, lustrous, yellowish brown or greenish yellow, with slightly swollen, pulvini and recurved petioles; leaves compressed, 1-2 cm. long, acute, slightly curved, slightly keeled on both sides, with white bands above, dark green and lustrous beneath; cones cylindric-oblong, 4-7.5 cm. long, light brown, or green tinged with brown before maturity; scales rhombic-oblong, erose and denticulate.

Sungkiang: *C. K. Chow 1078.*
Also distributed from Saghalin to N. Japan.

LARIX Miller

Deciduous trees with horizontal branches; bark thick, scaly; buds small, subglobose, with imbricate scales, the inner ones accrescent; leaves spirally arranged and remote on the long shoots, densely clustered on the lateral short spurs, linear, flattened, rarely nearly quadrangular; flowers monoecious, solitary, terminal; ♂ flowers globose to oblong, stalked or sessile, yellow, consisting of numerous short-stalked spirally arranged anthers; ♀ flowers subglobose, consisting of few or many 2-ovuled scales borne in the axils of larger usually scarlet bracts; cone subglobose to oblong; scales suborbicular to oblong, persistent on the axis, maturing in the first year; seeds 2 under each scale, nearly triangular, with large membranous wing; cotyledons usually 6.

About 10 species in the cooler regions of the N. Hemisphere, chiefly in the mountains.

LARIX SIBIRICA Ledeb. Fl. Alt. 4: 204. 1833.

Trees up to 40 m. high, with straight stem and rather short ascending branches; branchlets light yellowish gray; buds brown, at base very dark to nearly black; leaves similar to those of the ascending species, 2.5-3.5 cm. long; ♀ flowers usually green, sometimes whitish or brownish; cones ovoid, usually 3.5 cm. long, with about 30 scales truncate or rounded and entire at the margin, finely striate and tomentulose on the back, half-spreading at maturity; seed-wings not extending to the upper margin of the scales.

Sungkiang: *C. K. Chow.*

Distributed from western Russia to eastern Siberia.

PINUS Linnaeus

Evergreen trees with whorled spreading branches, rarely shrubby; bark furrowed or scaly; buds conspicuous, with numerous imbricated scales; leaves of 2 kinds, the primary leaves spirally arranged and usually reduced to small scarious bracts bearing in their axils, the acicular, semiterate or triangular secondary leaves borne on an un developed branchlets in clusters of from 2-5, rarely as many as 8 or reduced to 1, surrounded at base by sheaths of 8-12 buds-scales; only on young seedling plants and occasionally on shoots from the old wood the primary leaves are subulate and green; flowers monecious, the ♂ flowers axillary, clustered at base of the young shoot, catkin-like, yellow, orange or scarlet, composed of numerous spirally arranged 2-celled scales, each subtended by a small bract; cone subglobose to cylindric, symmetrical or oblique, with woody scales closely appressed before maturity; apex of the scales usually much thickened and the exposed part (apophysis) usually rhombic in outline, transversely keeled and in the middle usually with a prominent boss or umbo mostly terminated by a spine or prickle; in some species apex of the scale is flat and bears the spineless umbo at the end; seeds usually with long articulate or adnate wing, rarely with short wing or wingless; cotyledons 4-15.

About 80 species distributed throughout the N. Hemsiphere. The following species is very common in Northeastern China.

PINUS KORAIENSIS Sieb. et Zucc. fl. Jap. 2: 28, t. 116. 1842-'70.

Pyramidal trees up to 30 m. high; bark scaly, gray-brown or gray; branchlets with yellow-brown tomentum; winter-buds oblong-ovoid, dark chestnut-brown; leaves dark green, straight, 6-12 cm. long, serrulate; resin-ducts medial; cones short-stalked, 9-14 cm. long, conic-ovoid or conic-oblong, yellow-brown; scales with recurved obtuse apex.

Sungkiang: *C. K. Chow 1056.*

Also in Korea and Japan.

JUGLANDACEAE

JUGLANS Linnaeus

JUGLANS MANDSHURICA Maxim., Bull. Acad. Sci. St. Peterb. 18: 58. 1872.

Trees up to 20 m. high, with broad round head; branchlets glandular-pubescent;

leaflets 9-17, ovate-oblong to oblong, acute, serrulate, 7-18 cm. long, sparingly pubescent above at first, finally glabrous or nearly so, pubescent below and usually densely glandular-pubescent on the mid-rib and rachis; ♂ catkins about 10 cm. long; ♀ catkins 5-10-flowered; fruit subglobose or ovoid, pointed, 4.5-5.5 cm. long; nut ovoid, pointed, with 8 prominent, sharply edged ridges and irregular broken ridges between, 4-4 5 cm. long.

Sungkiang. *C. K. Chow 1059.*

Also in Amurland.

BETULACEAE

Among Mr. Chow's specimens there are three genera, of which the differences are given in the following key.

1 Nuts small, compressed and winged, 2 3 in axils of scales forming catkins, stamens 2-4, with 2-4 parted calyx ... *Betula.*
1 Nuts large, not compressed and not winged, usually enclosed in a foliaceous involucre forming spikes or clusters, stamens 3 13, without calyx ... 2
2 Fruit in pendulous slender spikes, buds elongated acute, ♂ flowers inclosed in scaly buds; leaves with 9 or more pairs of veins ... *Carpinus.*
2 Fruit in clusters, buds ovoid, obtuse or acute ♂ catkins naked during the winter, leaves ovate or orbicular-ovate with usually 5 8 pairs of veins ... *Corylus.*

BETULA Linnaeus

Deciduous trees or shrubs; buds with several imbricate scales; leaves petioled, usually ovate, doubly serrate or dentate to lobulate, with few to many parallel lateral veins; flowers monoecious, ♂ catkins elongated, formed in the autumn and remaining naked during the winter, every bract with flowers, each flower with a minute 4-parted calyx and 2 stamens, each stamen divided at apex; ♀ catkins cylindric or subglobose to oblong, each bract with 3 flowers, without calyx; fruit a minute nut, usually with membranaceous wings, at maturity dropping together with the 3-lobed bract from the slender rachis.

About 40 species in the N. Hemisphere, they are considered as valuable timber wherever they occur.

1 Bracts of strobiles with lateral lobes spreading or recurved, longer than the middle lobe, bark not white ... *B manshurica.*
1 Bracts of strobiles with the lateral lobes suberect, shorter than the middle lobe, bark white ... *B davurica*

BETULA MANDSHURICA (Regel) Nakai, Bot. Mag. Tokyo, 29: 42. 1915.

Tree up to 20 m. high; bark white; branchlets resinous glandular; leaves ovate, elliptic-ovate to deltoi-ovate, irregularly serrate, acute to short acuminate at apex, truncate to broad-cuneate at base, sparsely pilose above, paler and pilose on veins or sometimes with axillary tufts of hairs and densely glandular dotted beneath, 4-6 cm. long, 2-3.5 cm. broad; petioles 1-2.5 cm. long; strobiles cylindric, pendulous, puberulent; the middle lobe of bract irregular, shorter or as long as the spreading broad lateral lobes; wings of the fruit as broad as or broader than the nutlet.

Sungkiang: *C. K. Chow 1050.*

Also distributed in Korea and common in North China.

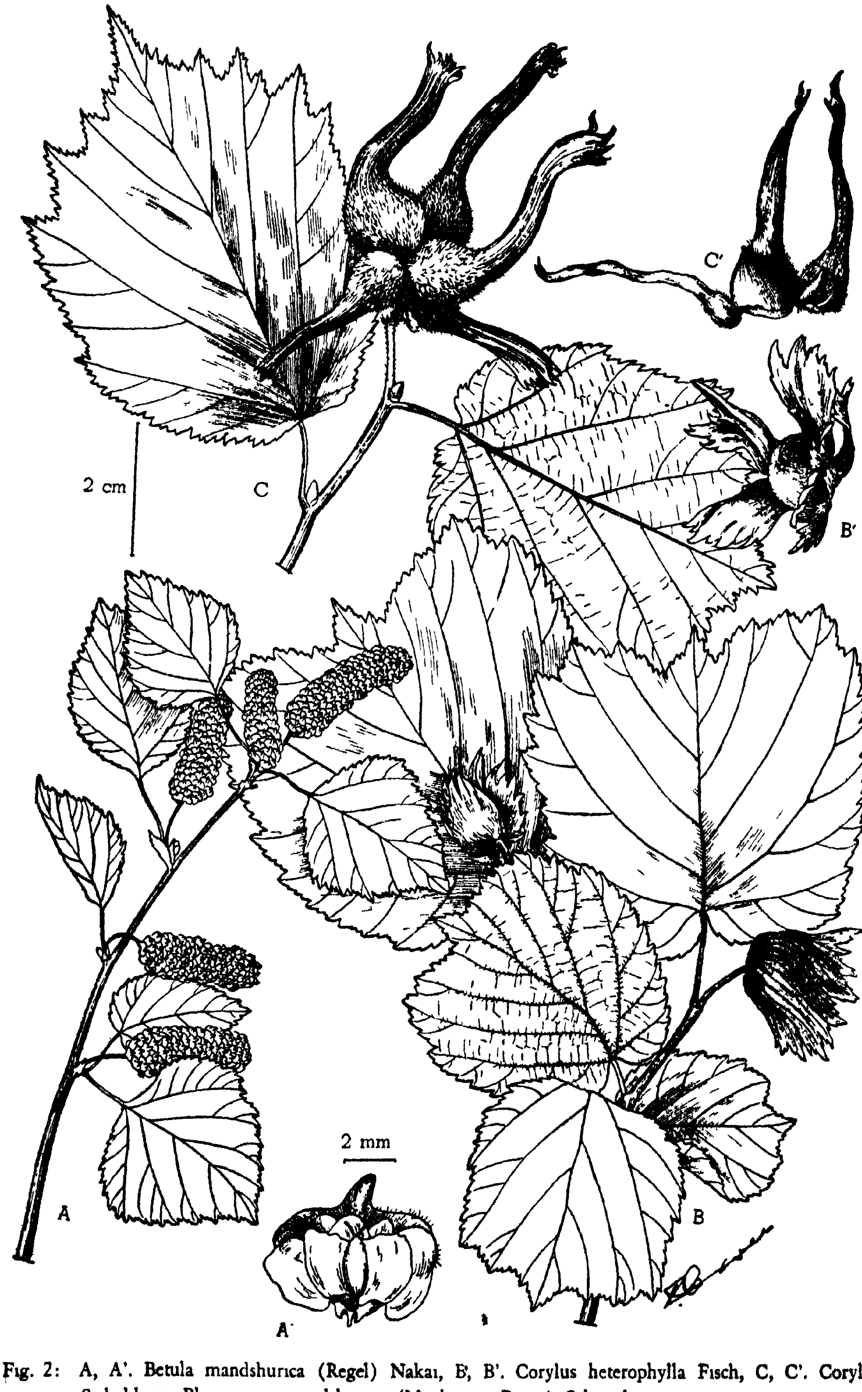

Fig. 2: A, A'. Betula mandshurica (Regel) Nakai, B, B'. Corylus heterophylla Fisch, C, C'. Corylus Sieboldiana Blume var. mandshurica (Maxim. et Rupr) Schneid.

BETULA DAVURICA Pall. Reise 3: Note-321, 421, t. K. k, fig. 4, a-b. 1776.

Trees up to 20 m. high; bark purplish brown, exfoliating in thin and small flakes; branches widely spreading; branchlets glandular pubescent, chestnut-brown, leaves narrowly ovate to rhombic-ovate, acute or shortly acuminate at apex, cuneate at base, irregularly dentate-serrate, pilose on both surfaces when young, finally glabrescent above, glandular-dotted beneath, 4-8 cm. long, 2.5-4 cm. broad; veins 6-8 pairs; petioles 5-15 mm. long, slightly pilose; strobiles trilobed, the middle lobe usually longer than the lateral ones, triangular in shape, the lateral lobes rounded and spreading; wings of the fruit about half or less than half as broad as the nutlet.

Sungkiang: *C. K. Chow 1159.*

Common in the province of Hopei and also in Japan.

CARPINUS Linnaeus

Deciduous trees or shrubs; bark gray, smooth or scaly; buds acute with many imbricate scales; branchlets slender; leaves more or less 2-ranked, with 2-24 pairs of straight lateral veins, usually double serrate; flowers opening in the spring with the leaves; ♂ catkins pendulous, inclosed in the bud during the winter; flowers without perianth, each bract with 3-13 stamens, 2-forked at apex; ♀ catkins terminal, slender, each bract with 2 flowers, each flower subtended by 2 bractlets; perianth adnate to the ovary, with 6-10 teeth at apex; style short, with 2 linear stigmas; fruit a ribbed nutlet subtended by a large bract.

There are about 30 species distributed in Asia, Europe and the North and Central America. We have several species in Northeastern China. The wood is very hard and tough, good in the making of tools.

CARPINUS EROSA Blume, Mus. Lugd.-Bat. 1: 308. 1850.

Trees up to 15 m. high, branchlets and petioles densely pilose when young, soon glabrous; leaves oblong-ovate or rarely ovate, acuminate at apex, cordate at base, irregularly dentate-serrate, subglabrous above, sparsely pilose on veins beneath, 7-12 cm. long, 3.5-6.5 cm. broad; veins impressed above, 15-20 pairs; petioles 1-2.5 cm. long; fruiting catkins 6.5-10 cm. long, with puberulous rachis; peduncle slender, about 2.5-4 cm. long; nut oblong, glabrous, about 4 mm. long.

Sungkiang: *C. K. Chow 1064, 1065 and 1052.*

From N. E. Asia southward to North China, and also recorded in the Hupeh province.

CORYLUS Linnaeus

Deciduous shrubs, rarely tree; buds usually obtuse or sometimes acute, protected by many imbricate scales; leaves generally ovate to rounded, usually doubly serrate, more or less pubescent, conduplicate in bud; flowers before leaves; ♀ catkin cylindric, pendulous, naked in the winter; flowers without perianth, stamens subtended by bract, each bract with 4-8 stamens, filaments bifid, anthers pilose at apex; ♂ inflorescence head-like, enclosed in a small scaly bud, with only the red styles protruding; ovaries with 1 rarely 2 ovules in each cell; style bifid from base; fruit a subglobose or

ovoid nut, with ligneous pericarp, included or surrounded by a large leafy variously toothed or dissected involucre, often tubular, in clusters at the end of the branchlets; cotyledons thick, fleshly, remaining inclosed in the nut.

About 15 species in the North America, Europe and Temperate Asia; they are often cultivated for their edible nuts and some as ornamentals. We have 2 species common in Northeastern China.

1. Involucre consisting of 2 distinct or partly connate bracts...................... *C. heterophylla.*
1. Involucre tubular .... *C. Sieboldiana Blume* var. *mandshurica.*

CORYLUS HETEROPHYLLA Fisch., Schtschagl. Anz. Entdeck. Phys. Chem. & Techzol. 8: 3. 1831. (Fig. 2: B and B').

Shrubs or small trees up to 7 m. high; branchlets and petioles glandular-hairy; leaves orbicular-ovate to obovate, abruptly acuminate from a nearly truncate apex, cordate or rounded at base, irregularly serrate and usually lobulate, particularly near apex, 5-10 cm. long, glabrous above, pubescent on the nerves beneath; petiole 1-2 cm. long; fruits usually 1-3; involucre campanulate, longer than the nut, striate glandular-setose near the base, with 6-9 triangular, entire or sparingly dentate lobes; nut subglobose, about 1.5 cm. across.

Sungkiang: *C. K. Chow 1001* and *1120.*

Distributed in the North and northwestern China and also in Japan.

CORYLUS SIEBOLDIANA *Blume* var. mandshurica (Maxim. et Rupr.) Schneid., Sargent's Pl. Wilson. 2: 454. 1916. (Fig. 2: A.)

A small tree up to 6 m. high; branchlets glabrous, finely pubescent when young; leaves ovate-oblong to nearly orbicular, lobulate at the upper portion, chartaceous, doubly serrate, abruptly truncate or acuminate at apex, cordate at base, sparsely pubescent above and beneath, 5-9 cm. long, 4-6.5 cm. broad; lateral veins about 6 pairs; petioles pilose, about 2.5 cm. long; ♀ flowers clustered, with involucre connate, becoming a long tube, irregularly toothed at the mouth, slightly constricted above the fruit, densely covered with yellow stiff hairs; fruit puberulous.

Sungkiang: *C. K. Chow 1032.*

Commonly grown in Japan, Korea and Northeastern China, southward to North China and the southwestern provinces.

ACERACEAE

Trees or shrubs; leaves opposite, simple or compound, estipulate; flowers ⚥ or ♀ ♂, mostly andro-polygamous, or andro-monoecious or dioecious, regular, small, in terminal or lateral racemes, panicles or cymes, sepals 4-5, imbricate, rarely connate, petals 4-5, imbricate or wanting; disk usually flat, intrastaminal or extrastaminal, rarely wanting; stamens 4-10, usually 8; ovary superior, 2-celled, 2-lobed, much flattened contrary to the partition; style with 2 stigmas; ovules 2 in each cell; fruit flat, winged, splitting into two 1-celled samaras; seed exalbuminous, with thin testa; embryo with flat, folded or rolled cotyledons.

2 genera about 115 species in the temperate regions of the N. Hemisphere.

Fig. 3: A. Acer mono Maxim., B. Acer ginnala Maxim., C. Acer tegmentosum Maxim., D. Acer barbinerve Maxim., E. Acer mandshurica Maxim., F. Acer triflorum Kom.

ACER Linnaeus

Deciduous, rarely evergreen trees, rarely shrubs; winter-buds with imbricate or with 2 outer scales; leaves opposite, petioled, simple and usually palmately lobed or 3-7-foliolate; flowers usually andro-monoecious or dioecious, 5-merous, rarely 4-merous, in racemes, panicles, cymes or corymbose; sepals sometimes connate; petals sometimes wanting; disk usually annular and large, rarely lobed or wanting; stamens 4-10, usually 8; styles or stigmas 2; fruit consisting of 2 long-winged compressed samaras.

About 115 species in the N. America, Asia, Europe and N. Africa, 88 species in China, several in Noreseastern China.

1. Inflorescence in corymbose or racemose panicles; leaves simple, usually lobed .... 2.
1. Inflorescence usually a simple cyme; leaves compound, trifoliate .... 6.
2. Nutlets flat or convex but not ridged .... 3.
2. Nutlets strongly convex or edged .... *A. barbinerve.*
3. Inflorescence corymbose or paniculate .... 4.
3. Inflorescence simple racemes .... *A. tegmentosum.*
4. Nutlets much flattened, smooth; leaf-lobes entire .... *A. mono.*
4. Nutlets convex, veined; leaf-lobes serrate or serrulate .... 5.
5. Leaves 5-lobed; inflorescence paniculate .... *A. ukurunduense.*
5. Leaves 3-lobed; inflorescence corymbiform .... *A. ginnala.*
6. Inflorescence glabrous; nutlets glabrous .... *A. manchuricum.*
6. Inflorescence pubescent; nutlets pubescent .... *A. triflorum.*

ACER MONO Maxim., Bull. Acad. Sci. St. Petersb. 15: 126. 1857. (Fig. 3: A.)

Deciduous trees up to 20 m. high; bark gray or brownish-gray to darkish-gray, very rough; branchlets slender, glabrous, newly grown ones green or purplish-green, matured ones gray or whitish-gray with rounded lenticels; winter-buds subglobose, glabrous or ciliated along the margin, with the inner scales pilose outside; leaves chartaceous, usually 5-lobed, truncate or subcordate at base, 6-8 cm. long, 9-11 cm. broad, glabrous, except yellowish or whitish pubescence on the veins or at the axils of the veins beneath; leaves entire, acuminate or subcaudate-acuminate, with obtuse or broad-obtuse sinuses; petioles 4-6 cm. long, slender, glabrous; flower numerous in glabrous terminal paniculate corymbs, about 4 cm. long and broad, with 1-2 cm. long peduncle; calyx ciliate, sepals 5, greenish-yellow, oblong, 2-3 mm. long; petals 5, whitish, elliptical or elliptic-obovate, 3 mm. long; stamens 8, shorter than the petals, inserted near the inner margin of the disk; ovary glabrous or glabrescent, rudimentary in the ♂ flowers, style glabrous, short, stigma revolute; pedicels about 1 cm. long, slender, glabrous; fruit purplish green while young, yellowish when matured; nutlets 1-1.3 cm. long, 8-10 mm. broad; wings oblong, spreading at obtuse angles or horizontally.

Sungkiang: *C. K. Chow 1022, 1023, 1080* and *1082.*

Distributed in the northern, northwestern and southwestern China, also in Korea.

ACER UKURUNDUENSE Trautv. et. Meyer, Middendorff Reise Aeuss. Nord. u. Oest.

Deciduous trees, 5-10 m. high; bark rough, yellowish-brown or blackish-brown; branchlets stout, purple or purplish-brown, with yellow pubescence while young; becoming brown or dark-brown and slightly pubescent while matured; winter-buds shortly conical, densely yellow pubescent; leaves truncate or subcordate at base, nearly rounded in

outline, 10-12 cm. long, 7-9 cm. broad, usually 5-lobed; lobes broadly ovate rarely triangular-ovate, acuminate, coarsely serrate, with broadly acute or obtusih teeth; sinuses acute, deep green, glabrescent above, pale green or yellowish-green beneath, with the primary veins slightly prominent, secondary veins reticulate, densely yellowish tomentose, especially on the veins; petioles 5-8 cm. long, slightly pubescent; flowers yellowish green, dioecious, in pubescent compact, erect, terminal racemose panicles, about 8-10 cm. long, with about 3 cm. long peduncles, from leafy branchlets; in the ♂ flower, sepals 5, yellowish-green, lanceolate, slightly pubescent; petals 5, yellowish-white; stamens 8, glabrous, exserted, inserted at the middle of the disk; disk glabrous, lobed; ovary rudimentary; pedicels slender, 5-8 mm. long, pubescent; fruiting panicle erect, with yellowish-brown fruits; nutlets flat, puberulent, 6 mm. in diameter; wings with nutlet 1.5-2 cm. long, 6 mm. broad, spreading erect.

Sungkiang: *C. K. Chow 1031* and *1051*.

Also in Korea, Sacchalin and Japan.

ACER GINNALA Maxim., Bull. Acad. Sci. St. Petersb. 15: 126. (Mél. Biol. 2: 415.) 1857. (Fig. 3: B.).

Acer tataricum Linn. var. *ginnala* Maxim., Mem. Pres. Acad. Imp. Sci. St. Petersb. div. sav. 9: 57 and 388 (Prim. Fl. Amur.). 1859, Bull Acad. Sci. St. Petersb. 26: 445 (Mél. Biol. 10: 604). 1880, Enum. Pl. Mongol. 138. 1889.

Deciduous trees usually 5 m. high; bark rough, gray, occasionally blackish gray or brownish gray, lenticels ovate or rounded; branchlets slender, glabrescent, purple or purplish-green while young, yellowish or yellowish-grey when matured; winter-buds small, brownish; scales imbricate, 4 pairs, villous on the margin; leaves chartaceous, rounded, truncate or subcordate, ovate or elliptic-oblong, 6-10 cm. long, 4-6 cm. broad, deeply 3-lobed or 5-lobed rarely not lobed; lobes acute to acuminate, irregularly incisively serrate or crenate-serrulate; sinuses acute or broadly acute, dark green above, glabrous, light green beneath, pubescent on veins while young; petioles 1-5 cm. long, slender, green or purplish green, slightly pubescent while young; flowers numerous in corymbs, androgynous, sepals 5, yellowish-green, marginally villous; petals 5, white; stamens 8 with glabrous filament and yellow anthers; disk glabrous, extrastaminal; ovary villous, rudimentary in the ♂ flowers, style glabrous with short stigmas; pedicels slender, slightly villous; fruit yellowish-green or brownish-green; nutlets villous while young; strongly veined; wings including the nutlet 2.5-3 cm. long, 8-10 mm. broad, parallel or widest at the middle, spreading erectly or at acute angles.

Sungkiang: *C. K. Chow 1030* and *1059*.

Distributed commonly in the northern, northwestern and eastern China and also in Korea and Japan.

ACER TEGMENTOSUM Maxim., Bull. Acad. Sci. St. Petersb. 15: 125. 1857, Mém. Pres. Acad. Sci. St. Petersb. div. sav. 9: 66 (Prim. Fl. Amur.). 1859, Bull. Acad. Sci. St. Petersb. 27: 441 (Mél. Biol. 10: 415 and 597). 1880. (Fig. 3: C.)

Deciduous medium-sized trees; bark gray or dark gray, striped; branchlets glabrous, those of the present year purple or purplish-green, those of more than one year old yellowish-green or grayish-brown; winter-buds ellipsoid; scales pubescent outside; leaves

chartaceous, roundish-ovate, 10-12 cm. long, 7-9 cm. broad, doubly serrulate, rounded or subcordate at base, usually shallowly 3-lobed, rarely with 2 small basal lobes; lobes acuminate; sinuses widely obtuse; deep green above, glabrous; pale green beneath, with yellowish barbate hairs at the axils of the nerves; petioles 4-7 cm. long, glabrous; flowers andro-monoecious, yellowish-green, in slender, glabrous, pendulous racemes; sepals 5; petals 5; stamens 8, glabrous, rudimentary in ♀ flower; disk glabrous intrastaminal; ovary glabrous, rudimentary in the ♂ flower, style short, stigmas slightly pubescent and turbinate; fruit glabrous, yellowish brown; nutlets flat or slightly convex; wings with the nutlet 2.5-3 cm. long, 1-1.3 cm. broad, spreading at a wide angle or nearly horizontal; pedicels about 5 mm. long, very slender.

Sungkiang: *C. K. Chow 1045.*

Also in Korea.

ACER BARBINERVE Maxim., Bull. Acad. Sci. St. Petersb. 12: 227 (Mél. Biol. 6: 369). 1867, 26: 439 (Mél. Biol. 10: 593). 1880. (Fig. 3: D.)

Deciduous trees about 5 m. high; bark smooth, grayish, grayish-yellow or grayish-brown; branchlets slender, new growth greenish or greenish purple, sparingly pubescent, matured ones grayish-yellow or greenish-brown, glabrescent; leaves membranaceous, roundish-ovate in outline, 8-10 cm. long, 6-8 cm. broad, cordate or subcordate at base, 5-lobed; leaves shortly acuminate, doubly serrate with coarsely obtuse teeth; sinuses acute; deep-green above, glabrescent; pale-green beneath, hirsute-pubescent on the veins; petioles 4-6 cm. long, slender, pubescent; flowers in racemes, yellowish-green, dioecious; ♀ racemes nodding, with small bracts on puberulous peduncles about 4 cm. long, from terminal leafy branchlets of the present year; ♂ racemes usually 5 or 6, flowers forming a subsessile fascicle; sepals 4, slightly ciliate on the margin; petals 4, contracted at base; stamens 4, glabrous, slightly longer than the petals, none in the ♀ flower; disk 4-lobed, glabrous, intrastaminal; ovary glabrous, none in the ♂ flower; style glabrous, with revolute stigmas; fruit greenish or greenish-yellow, usually 5 or 7 in pendulous racemes, fruiting inflorescence about 5 cm. long; nutlets 1 cm. long, 8 mm. broad, sublobose strongly veined, rugose; wings introse falcate, slightly contracted at base, 3-3.5 cm. long, 1 cm. broad; spreading at obtuse angles; pedicels 1-2 cm. long, slender, glabrous.

Sungkiang: *C. K. Chow 1018, 1033* and *1098.*

Also in Korea.

ACER MANDSHURICUM Maxim., Bull. Acad. Sci. St. Petersb. 12: 228 (Mél. Biol. 6: 371). 1867, 26: 450 (Mél. Biol. 10: 610) 1880. (Fig. 3: E.)

Deciduous trees up to 10 m. high, or higher; bark rough; branchlets glabrous, purplish-yellow or purplish-brown for this year's growth, gray or dark gray for several year's growth; leaves trifoliate; leaflets oblong to oblong-lanceolate, acuminate, 5-10 cm. long, 2-3 cm. broad, the middle one slender-stalked, the lateral ones short-stalked, obtusely serrate, dark green above, glaucous beneath and pubescent on the midrib otherwise glabrous; petiole glabrous, 6-10 cm. long, flowers greenish-yellow, in 3-5-flowered cymes; fruit glabrous; wings spreading at a right or obtuse angle, with the thick reticulate nutlets 3-3.5 cm. long; nutlets, about 5 mm. long and broad, globose, strongly convex.

Sungkiang: *C. K. Chow 1016.*

ACER TRIFLORUM Kom., Act. Hort. Petrop. 18: 430. 1901, 22: (Fl. Mandshur. 2) 728, fig. 15. 1904. (Fig. 3: F.)

Deciduous trees up to 10 m. high; branchlets soon glabrous, those of the more than one year old dark red or dark brown; winter-buds small, with ciliate scales; leaves trifoliate; leaflets oblong-ovate to oblong-lanceolate, 4-9 cm. long, 2.5-3.5 cm. broad, entire or with 1-3 coarse teeth, glaucous beneath and glabrous except pilose along the midrib; petiole 3-6 cm. long, sparingly pilose; flowers in 3-flowered cymes; pedicels pubescent; peduncle short; fruit greenish-yellow, nutlets subglobose, wings nearly straight, spreading at an obtuse angle, with the densely pubescent thick nutlet 3.5-4 cm. long.

Sungkiang: *C. K. Chow 1015.*

Also in Korea.

TILIACEAE

Trees, shrubs or herbs, often with stellate or fascicled pubescence; leaves alternate, rarely opposite, entire or lobed, stipulate; flowers ⚥, regular; sepals 5, rarely 3 or 4, free or connate, usually valvate; petals as many, convolute, valvate or imbricate, rarely wanting; stamens 10 or more, hypogynous; filaments distinct or connate at base; anthers 4-celled, opening by slits, rarely pores; staminodes sometimes present; ovary superior, 2-10-celled; cells with 1 to several ovules; style 1, stigma radiate; fruit a capsule or indehiscent and either nut-like or drupaceous, rarely a berry or separating into drupelets; seed albuminous.

35 genera with about 300 species in the tropical, subtropical and temperate regions. We have found one genus among Mr. C. K. Chow's specimens.

TILIA Linnaeus

Deciduous trees, mostly with fascicled hairs; winter-buds large, obtuse, with few or several scales; terminal bud wanting; leaves alternate, 2-ranked, slender-petioled, usually cordate or truncate to broadly cuneate and oblique at base, serrate; stipules caducous; flowers yellowish or whitish, fragrant, in drooping cymes or cymose panicles; peduncle adnate to a large ligulate bract; sepals 5, distinct; petals 5, imbricate, with staminode opposite to them; stamens many, distinct or in 5 fascicles opposite the petals; filaments usually forked at apex; ovary 5-celled, each carpel opposite the petals; cells 2-ovuled; style slender, with 5-lobed stigma; fruit globose or ovoid, nutlike, usually with 1-3 seeds; cotyledons palmately 5-lobed.

About 30 species in the temperate regions of the North Hemisphere. We have three species in Northeastern China.

1. Leaves and bracts glabrous or sparsely pubescent. . . . . 2.
1. Leaves and bracts densely pubescent; usually obliquely cordate at base. . . . . . . *T. mandshurica.*
2. Leaves ovate grossly serrate, base broadly cuneate to subrounded. . . . . *T. mongolica.*
2. Leaves broadly ovate to rounded, base cordate to truncate. . . . . *T. amurensis.*

TILIA MONGOLICA Maxim., Bull. Acad. Sci. St. Petersb. 26: 433. 1880. (Fig. 4: A, A'.)

Deciduous tree up to 10 m. high; young branchlets glabrous, reddish; leaves reddish

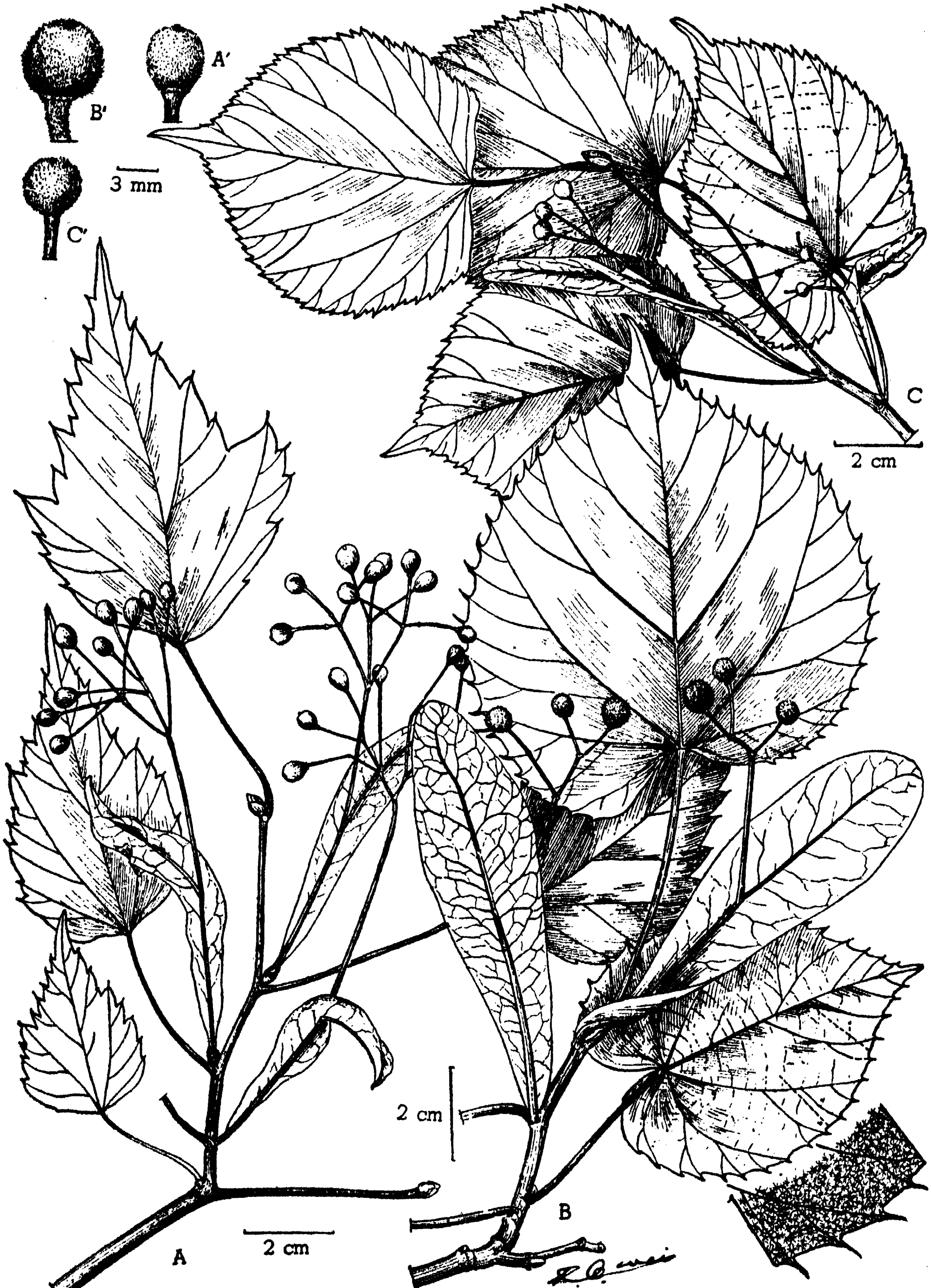

Fig. 4: A, A'. Tilia Mongolica Maxim., B, B'. Tilia mandshurica Rupr. et Maxim., C, C'. Tilia amurensis Kom.

when unfolding, suborbicular to ovate, 4-9 cm. long, 3-6 cm. broad, coarsely serrate and sub-tri-lobed, dark green and lustrous above, glaucescent and glabrous beneath, usually with axillary tufts of hairs; petiole reddish, 2-4.5 cm. long; cyme 6-20-flowered; bract stalked; fruit subglobose, thickwalled.

Sungkiang: *C. K. Chow 1119.*

Also in Mongolia and Hopei province.

TILIA AMURENSIS Kom., Act. Hort. Petrop. 25: 24. 1907, 39: 87. 1923. (Fig. 4: C, C'.)

Deciduous tree up to 9 m. high; bark thin, scaly; branchlets slender, reddish-gray, glabrous; leaves broad-ovate, subcordate or truncate, serrate with acuminate teeth; green above, whitish glaucous beneath, with axillary tufts of hairs on veins, 3-7.5 cm. long, 3-5.5 cm. broad; flowers 3-20, sometimes with incompletely developed staminodes; fruit globose.

Kirin: Y. *Yabe,* Aug. 16, 1918. Liaotung: Y. *Yabe,* Aug. 14, 1917 and June 27, 1918. Sungkiang *C. K. Chow 1029, 1058, 1101* and *1141.*

Also in Korea and Siberia.

TILIA MANDSHURRICA Rupr. et Maxim., Bull. Acad. Sci. St. Petersb. 15: 124. 1856. (Fig. 4: B, B'.)

Deciduous tree up to 20 m. high; young branchlets and buds with brownish tomentum; leaves orbicular-ovate, 8-15 cm. long, 6-9 cm. broad, short-acuminate, usually oblique cordate at base, coarsely serrate with long-pointed teeth, sometimes indistinctly lobed, sparingly pubescent above, grayish or whitish tomentose beneath, without axillary tufts of hair; petiole 3-7 cm. long, tomentose; flowers 7-10 in pendulous brownish tomentose cymes; bract stout, tomentose beneath; fruit globose, 5-ribbed toward base or indistinctly ribbed.

Liaotung: Y. *Yabe,* Aug. 15, 1917. Sungkiang: *C. K. Chow 1137.*

Also occurs in the North and Northwestern China, and also in Japan.

ARALIACEAE

Perennial herbs, shrubs or trees, rarely scandent, often prickly; stems with large pith; leaves alternate, petiolate, simple, lobed or compound; stipules present or wanting, adnate to the petiole or connate into a sheath, sometimes very small; flowers regular, small, ⚥ or ♂ ♀ often dioecious, epigynous, in umbels or heads rarely in racemes or heads rarely in racemes or spikes often forming compound inflorescence; bracts and bracteoles small or inconspicuous, deciduous or persistent; pedicels usually continuous with the calyx or articulate under the flower; sepals small or obsolete; petals 5, valvate or imbricate, sometimes cohering at apex and falling off as a cap; stamens 5, inserted at the edge of the disk; ovary 2-15-celled; cells 1-ovuled; styles as many as carpels, often connate; fruit baccate or drupaceous, rarely splitting into segments; seeds albuminous, with small embryo; endosperm uniform or ruminated.

About 60 genera and more than 800 species in the tropical and temperate regions of both hemispheres.

ACANTHOPANAX Miquel

Shrubs or small trees, glabrous or hairy, usually priskly, sometimes unarmed; leaves digitately compound; stipules wanting or inconspicuous; flowers ⚥ or ♂ ♀, in terminal umbels; umbels solitary or paniculate; pedicels articulate below the flower; calyx minutely 5-dentate; petals 5, rarely 4, valvate; stamens 5, with oblong anthers; ovary 2-celled, rarely 3-5-celled; styles 2-5, distinct or connate at base; fruit laterally compressed or subglobose, 2-5-seeded; seeds compressed; endosperm uniform.

About 30 species in the eastern Asia and the Himalayan regions; one in the Philippines.

ACANTHOPANAX SENTICOSUS (Rupr. et Maxim.) Harms, Engl. Prantl. Nat. Pflanzenfam. 3(8): 50. 1894.

Deciduous shrubs or trees up to 5 m. high, with upright sparingly branched stems, usually densely covered with slender bristles or prickles; leaflets 5, sometimes 3, short-stalked, elliptic-obovate to oblong, 4-10 cm. long, 2-4.5 cm. broad, short-acuminate, cuneate, sharply and doubly serrate, dark green and with scattered hairs above, light green beneath and brownish pubescent on the veins when young; petioles slender, 6-12 cm. long; petiolules 5-20 mm. long; umbels terminal, solitary or 2-4 together, globose, many-flowered, 3-4 cm. across, on slender peduncles 5-7 cm. long; pedicels 1-2 cm. long; flowers purplish-yellow; fruit subglobose, 8 mm. across, 5-angular.

Sungkiang: *C. K. Chow 1164.*

Distributed commonly in the North China and also in Korea, Sachalin and Japan.

OLEACEAE

Shrubs or trees; leaves opposite, rarely alternate, simple or pinnate, exstipulate; flowers ⚥ or ♂ ♀, regular; calx 4-lobed or 4-parted, rarely 5-16-lobed; corolla gamopetalous, 4-lobed or rarely 6-12-lobed, sometimes with distinct petals or wanting; stamens 2, rarelly 3-5, adnate to corolla and alternate with the lobes; ovary superior, 2-celled, 2 ovules in each cell; style 1 or wanting, with simple or 2-lobed stigma; fruit a drupe, berry, capsule or samara; seeds anatropous, with large straight embryo, with or without albumen.

About 20 genera with over 400 species in the temperate and tropical regions.

FRAXINUS Linnaeus

Deciduous trees, rarely shrubs; winter-buds often superposed, with 1 or 2 pairs of outer scales, brown or black in color and scurfy, outer pairs sometimes foliaceous; leaves pinnate, rarely reduced to 1 leaflet; flowers ⚥ or ♂ ♀, small, in panicles; calyx small, 4-lobed or -parted or wanting; corolla 2-6, usually 4-distinct petals, rarely connate at base, or wanting; stamens 2; ovary 2-celled; stigmas 2; fruit 1-seeded samara, seed oblong, albuminous.

About 65 species in the North Hemisphere, few in Mexico and Java.

1. Inflorescence on this year's branchlets in terminal or leaf-axil panicles, with or after the leaves; leaflets stalked; samara 3-6 mm. broad .... *F. chinensis* Roxb. var. *rhynchophylla* (Hance) Hemsl.

Fig. 5. A. Fraxinus chinensis Roxb var rhynchophylla (Hance) Hemsl B Fraxinus mandshurica Rupr.

1. Inflorescence on last year's branchlets, usually before leaves; leaflets subsessile; samara 8-9 mm. broad .... *F. mandshurica* Rupr.

FRAXINUS CHINENSIS Roxb. var. rhynchophylla (Hance) Hsmsl., Jour. Linn. Soc. Bot. 26: 86. 1889. (Fig. 5: A.)

Deciduous trees up to 15 m. high; winter-buds brownish-black; leaflets 5-7, usually 5, petiolulate, broad-ovate to obovate, rarely oblong-obovate, 1.5-15 cm. long, 1-7.5 cm. broad, acuminate, rarely obtusish, coarsely crenate-serrate, rarely subentire, usually pubescent on the veins beneath, rarely glabrous; rachis usually rufous-pubescent at the nodes; panicles shorter than leaves; samara 10-38 mm. long, 3-6 mm. broad.

Liaotung: *Y. Yabe.*

Distributed also in the province, Hopei.

FRAXINUS MANDSHURICA Rupr., Bull. Acad. Sci. St. Petersb. 15: 371. 1857. (Fig. 5: B.)

Deciduous trees up to 30 m. high; branchlets obtusely quadrangular, glabrous; winter-buds dark-brown; leaflets 9-11, sessile, oblong-ovate to oblong-lanceolate, 7-12 cm. long, 1.5-3.7 cm. broad, long acuminate, cuneate, sharply serrate, dull-green above and often sparingly hispid, usually pilose or hispid on the veins beneath, rufous-tomentose at base; rachis slightly winged; flowers dioecious; samara oblong-lanceolate, 2.7-3.5 cm. long, 8-9 mm. broad.

Sungkiang: *C. K. Chow 1099.*

Also distributed in Korea and Japan.

THE EFFECT OF INDOLEACETIC ACID UPON THE EARLY GROWTH OF PHASEOLUS SEEDLINGS IN DARK AND IN LIGHT

Y. W. TANG

Literature dealing with auxin and the growth of plants under different light conditions indicates that different plants behave differently under auxin treatment in light and in dark. Using *Raphanus* as material van Overbeek (7) has been shown that in light a given amount of indoleacetic acid produces less elongation than in dark. Thimann and Skoong (12) who applied indoleacetic acid to the stem of *Vicia faba* in light and in dark, found that the stem of *V. faba* is less sensitive to auxin in light. King (3) revealed that indoleacetic acid stimulates the elongation of *Elodea* segments both in light and in dark, however, the increase in length is being greater in dark than in light. On the other hand, van Overbeek (8) demonstrated that the sensitivity of *Avena* coleoptiles to indoleacetic acid is greater in light than in dark. Galston (2), using sterile culture technique, concluded that indoleacetic acid stimulated the elongation of *Asparagus* stem in light while inhibites elongation in dark. It seems that in some tissues, light appears to be the cause of a lower response while in other tissues, the

reverse effect is found. This paper reports on the effect of indoleacetic acid upon the early growth of bean seedlings in dark and in light with special emphasis on the elongation of the hypocotyls.

MATERIAL AND METHOD

Bean (*Phaseolus vulgaries,* Kentucky wonder pole climber) seeds were germinated in sand for 5-6 days. From a large number of germinated seeds, uniform individuals were selected for treatment, when the primary leaf of the seedling began to expand. A small piece (about 2 mm^3) of the apical end of each cotyledon was removed and a paste of indoleacetic acid in lanolin was smeared on the cutting surface. The concentration of the lanolin mixture was 1%, i, e., 10 mg. of indoleacetic acid per gram of lanolin. Dosages of various concentrations of the auxin were used in one set of the experiments for comparison. Pure lanolin was used as control. Measurements of the length of both treated and controlled hypocotyls were made periodically. In some cases, the length of the first and the second internode and their dry weight were also recorded. To study the effect of light, alternate durations of light and dark were employed in another set of the experiments.

EXPERIMENTAL RESULTS

THE EFFECT OF INDOLEACETIC ACID UPON THE EARLY GROWTH OF GREEN BEAN SEEDLINGS IN LIGHT. Seeds were germinated in light. On the sixth day, 1% indoleacetic acid in lanolin was applied on the cutting surface of the cotyledons; pure lanolin was used as control. The results are given in tables 1, 2, and fig. 1; they all show that indoleacetic acid accelerates the elongation of the hypocotyls. The increase was 30% over the control 40 hours after treatment. Regarding the elongation of the first and second internodes, inhibition was evident in the presence of indoleacetic acid. The length of the treated first internode was less than half of the control 88 hours after treatment, when the latter had reached its maximum length while the former kept on to elongate for another 24 hours. Therefore, the actual growing period of the treated first internode was longer than that of control inspite of the fact that the final length of the former was less than the latter. The second internode of the control began to elongate at the 7 hours after treatment with pure lanolin but there was no growth at all at the end of the experiment for the indoleacetic acid treated plant. The growth of the primary leaf was also inhibited in the presence of indoleacetic acid as shown in fig. 1. Hypocotyls of the treated plants were thicker than that of control, yet the dry weight of the hypocotyls, the first and second internodes and the primary leaves of both treated and controlled plants were similar. It can be supposed that between the hypocotyls and the parts above the cotyledons, a compensative utilization of food material from the cotyledons may exist for their early growth. If more food for the stimulative growth induced by the application of indoleacetic acid should move downward there would be less material available for the development of the primary leaf, first internode, and etc. This supposition was further strengthened by the following experiment.

TABLE 1. THE EFFECT OF INDOLEACETIC ACID UPON THE EARLY GROWTH OF GREEN BEAN SEEDLINGS IN LIGHT. CONCENTRATION OF INDOLEACETIC ACID 1%. EACH FIGURE REPRESENTS THE SUM OF 32 PLANTS.

Hours after treatment	Length of hypocotyls (mm.)		Length of 1st. internode (mm.)		Length of 2nd. internode (mm.)	
	Control	Treated	Control	Treated	Control	Treated
0	3363	3360	—	—	—	—
6	4059	4594	—	—	—	—
12	4408	5267	—	—	—	—
18	4587	5503	841	550	—	—
24	4656	5643	1084	605	—	—
32	4746	5738	1395	625	—	—
40	4759	5786	1631	672	—	—
48	—	—	1888	744	—	—
56	—	—	2175	855	—	—
64	—	—	2324	951	217	—
72	—	—	2421	1074	231	—
80	—	—	2470	1165	496	—
88	—	—	2546	1254	634	—
96	—	—	—	1313	994	—
112	—	—	—	1345	1281	—
120	—	—	—	1375	1539	—
128	—	—	—	—	1729	—

TABLE 2. THE EFFECT OF INDOLEACETIC ACID UPON THE ACCUMULATION OF SOLID MATTER BY THE SHOOT OF GREEN BEAN SEEDLINGS. EACH FIGURE REPRESENTS THE SUM OF 32 PLANTS.

Plant tissues	Controal	Treated
	Dry weight (mg.)	
Hypocotyls	1892	2870
1st. and 2nd. internodes	818	337
Primary leaves	1710	843
Sum	4421	4050

THE EFFECT OF INDOLEACETIC ACID UPON THE DEVELOPMENT OF THE PRIMARY LEAF AND FIRST INTERNODE OF SEEDLINGS WITHOUT HYPOCOTYLS. It has been shown that indoleacetic acid applied on the cutting surface of the cotyledons accelerates the elongation of the hypocotyls but inhibites the development of the other parts above the cotyledons. It would be interesting to note the behavior of the parts above the cotyledons when they are treated with indoleacetic acid-lanolin mixture in the absence of the hypocotyl. 5 days old seedlings separated from their hypocotyls were used in this experiment. 1% indoleacetic acid in lanolin was applied on the cutting surface of the cotyledons, while pure lanolin was used as control. After treatment, the seedlings without their hypocotyls were cultivated in Petri dishes, with each containing six plants for further development and observation in 10 cc. of distilled water; the distilled water was renewed daily. The length of the first internode and dry weight of the primary leaf and first internode

were measured and determined 6 days after cultivation. The results are given in table 3. By analyzing the data, it is evident that the inhibitory effect of indoleacetic acid upon the development of primary leaf and first internode played no important part as to be negligible.

Fig. 1. The effect of indoleacetic acid upon the early growth of green bean seedlings in light for 5 days after treatment. The left two seedlings were treated with indoleacetic acid and right two with pure lanolin as control.

TABLE 3. THE EFFECT OF INDOLEACETIC ACID UPON THE DEVELOPMENT OF THE PRIMARY LEAF AND FIRST INTERNODE OF BEAN SEEDLINGS WITHOUT HYPOCOTYL. CONCENTRATION OF INDOLEACETIC ACID 1%. EACH FIGURE REPRESENTS THE SUM OF 18 PLANTS.

	The length of first internode (mm.)	Dry weight (mg.)	
		Primary leaves	1st. internodes
Control	653	1644	539
treated	628	1446	472

THE EFFECT OF INDOLEACETIC ACID UPON THE EARLY GROWTH OF ETIOLATED SEEDLINGS CULTIVATED IN DARK. Dealing with the sensitivity of plants produced by auxin in light

conditions, as mentioned above, authors claimed different results. By the above experiment, it is shown that indoleacetic acid accelerates the elongation of green hypocotyls of bean plant in light. Whether this acid does the same upon the etiolated hypocotyls in dark or not is the object of the following experiment. Seeds were germinated in dark for 5 days. Twenty etiolated seedlings were divided into two groups. One percent of indoleacetic acid in lanolin was applied to the cutting surface of the cotyledons of one group and pure lanolin to the other as control. In this experiment, growth measurement were made twice with one initial determination. Table 4 and 5 represent the results. The elongation of the hypocotyls was inhibited after the application of indoleacetic acid, the inhibitory percentage being 100 at the end of the experiment. Growth in thickness of the etiolated hypocotyls was, however, accelerated. As to the development of the primary leaf and first internode of the treated plant, the results were similar to that of green seedlings.

TABLE 4. THE EFFECT OF INDOLEACETIC ACID UPON THE EARLY GROWTH OF ETIOLATED BEAN SEEDLINGS CULTIVATED IN DARK. CONCENTRATION OF INDOLEACETIC ACID 1%. EACH FIGURE REPRESENTS THE SUM OF 18 PLANTS.

Hours after treatment	The length of hypocotyls (mm.) Control	Treated	The length of 1st. internode (mm.) Control	Treated
0	1027	1035	—	—
24	2147	1505	—	—
48	2795	1708	451	53

TABLE 5. THE EFFECT OF INDOLEACETIC ACID UPON THE ACCUMULATION OF DRY MATTER OF ETIOLATED BEAN SEEDLINGS CULTIVATED IN EACH FIGURE REPRESENTS THE SUM OF 10 PLANTS.

Tissues	Control	Treated
	Dry weight (mg.)	
Hypocotyls	1045	980
Primary leaves	166	72
First internodes	110	23
Sum	1321	1075

CONCENTRATION EFFECT OF INDOLEACETIC ACID UPON THE ELONGATION OF GREEN AND ETIOLATED HYPOCOTYLS CULTIVATED IN LIGHT AND IN DARK. Previous experiments show that indoleacetic acid stimulates the elongation of green hypocotyls in light but inhibites the increase in length of etiolated hypocotyls in dark. However, the transverse dimension is enlarged in light and in dark for both etiolated and green hypocotyls. The question may arise whether the concentration of indoleacetic acid is too high for the etiolated bean plants. A series of indoleacetic acid in different concentrations were used and the results were tubulated in tables 6 and 7. As the tables show that in light, the greater the concentration of indoleacetic acid, the longer, the green hypocotyls, but the reverse results were obtained for etiolated hypocotyls in dark.

TABLE 6. CONCENTRATION EFFECT OF INDOLEACETIC ACID UPON THE ELONGATION OF GREEN HYPOCOTYLS CULTIVATED IN LIGHT. EACH FIGURE REPRESENTS THE SUM OF 13 PLANTS.

Concentration of indoleacetic acid	The length of hypocotyls (mm.) Hours after treatment		
	0	24	48
0	1403	1563	1738
0.01%	1376	1625	1801
0.04%	1362	1672	1824
0.20%	1426	1977	2012
1.00%	1344	2019	2160

TABLE 7. CONCENTRATION EFFECT OF INDOLEACETIC ACID UPON THE ELONGATION OF ETIOLATED HYPOCOTYLS CULTIVATED IN DARK. EACH FIGURE REPRESENTS THE SUM OF 10 PLANTS.

Concentration of indoleacetic acid	The length of hypocotyls (mm.) Hours after treatment		
	0	24	48
0	997	1890	2598
0.01%	1020	1951	2546
0.04%	1085	1759	2276
0.20%	1029	1632	1946
1.00%	1043	1513	1796

THE EFFECT OF INDOLEACETIC ACID UPON THE ELONGATION OF ETIOLATED HYPOCOTYLS CULTIVATED IN LIGHT AND GREEN HYPOCOTYLS CULTIVATED IN DARK. The above results show that indoleacetic acid accelerates the elongation of hypocotyls of green bean seedlings in light but inhibites the elongation of etiolated hypocotyls in dark. It would be interesting to investigate the effect of indoleacetic acid upon the elongation of green hypocotyls in dark and etiolated hypocotyls in light. The following experiment is designed for this purpose. Bean seeds were germinated in dark for 6 days and in light for 5 days. Both green and etiolated seedlings were carefully selected for treatment. After the application of indoleacetic acid on the cutting surface of the cotyledons, the green hypocotyls were cultivated in dark and the etiolated in light. Pure lanolin was used instead of indoleacetic acid-lanolin mixture as control. In addition to the initial measurement of the hypocotyls, further growth was determined twice after treatment. Tables 8 and 9 represent the results. In dark the growth of green hypocotyls of the treated bean

TABLE 8. THE EFFECT OF INDOLEACETIC ACID UPON THE ELONGATION OF GREEN HYPOCOTYLS CULTIVATED IN DARK. CONCENTRATION OF INDOLEACETIC ACID 1%. EACH FIGURE REPRESENTS THE SUM OF 10 PLANTS.

Hours after treatment	The length of hypocotyls (mm.) Control	Treated
0	914	912
18	1631	1772
42	1851	1887

TABLE 9. THE EFFECT OF INDOLEACETIC ACID UPON THE ELONGATION OF ETIOLATED HYPOCOTYLS CULTIVATED IN LIGHT. CONCENTRATION OF INDOLEACETIC ACID 1%. EACH FIGURE REPRESENTS THE SUM OF 10 PLANTS.

Hours after treatment	The length of hypocotyls (mm.)	
	Control	Treated
0	1305	1303
24	1831	1641
48	1911	1728

Seedlings is slightly better than that of the control, the increase percentage being less than 10. In case of etiolated seedlings which has been grown in light after treatment, the reverse results were obtained. The difference of hypocotyls elongation between the control and treated seedlings is also small.

DISCUSSION

The present experimental results show that indoleacetic acid accelerates the elongation of green hypocotyls but inhibites the growth of parts above the cotyledons (tables 1 and 2). On the contrary, in the absence of hypocotyls, the development of parts above the cotyledons is almost the same as the control (table 3). The author, therefore, suggests that there may exist a compensative utilization of food material form the cotyledons as mentioned above. Owing to the basipetal translocation and stimulative effect of indoleactic acid, a large portion of available food from the cotyledons may be exhausted for the excessive growth of the hypocotyls. The raw material for the development of the parts above the cotyledons is, therefore, limited. Studying willow cutting, Loo and Tang (6) found another compensative phenomemon between the development of bud and the root formation. When the paste of indoleacetic-acid-lanolin mixture was applied on the apical cutting surface of willow stem, the root formation at the basal end was accelerated whereas the growth of bud was completely inhibited. Whether there is any co-relation between the basipetal translocation of indoleacetic acid and the mobilization of available food remains to be solved.

As to the effect of auxin to plant growth in light and in dark, most investigators (van Overbeek, 1933; 1936; Thimann and Skoog, 1934; King, 1943; Galston, 1947;) took the increase in length as the criterion and obtained contradictory results with different plants. The present results show that indoleacetic acid accelerates the elongation of green hypocotyls in light but inhibites increase in length of etiolated hypocotyls in dark. By examining the dry weight determinations, the solid substance per unit length of treated hypocotyls both in light and in dark is more than that of control (tables 1, 2, 4 and 5), although the total dry weight of the etiolated and treated hypocotyls cultivated in dark is nearly the same as the control. Besides, indoleacetic acid increases the total dry weight of the green hypocotyls in light after treatment. Therefore, the conclusion of the inhibitory effect of indoleacetic acid on the growth of etiolated hypocotyls holds true only in the increase of length. It is worthy of note that, in the absence of light, the stimulative effect of indoleacetic acid on the elongation of green hypocotyls is

diminished. This facts can be proved further by the finding of Tang and Bonner (9, 10). They found, in several plant tissues, an indoleacetic-acid-inactivating enzyme; this was formed only in the absence of light. Thus the decreased elongation of green hypocotyl cultivated in dark might be partially due to the inactivation of indoleacetic acid by this enzyme. Still, it is very difficult to explain how could indoleacetic acid in various concentrations inhibit the elongation of etiolated hypocotyls in dark and while in the presence of light, the inhibitory effect diminished considerably (table 9). However, agreement could be reached if Larson's view (4, 5) on neutral growth substance of etiolated pea is taken into consideration. This neutral compound, as stated by Larson, is not destroyed by the indoleacetic-acid-inactivating enzyme and may readily convert into sufficient auxin for the elongation of the etiolated hypocotyls. The concentration of growth hormone of etiolated tissue would high enough to be above the optimum after the application of indoleacetic acid and thus caused inhibition in elongation. Boysen Jensen (1) made the same suggestion to explain root inhibition. Another suggestion came from Went (12) who claimed that the action of auxin was exerted on the transversed walls of the cells and thus caused thickening instead of elongation. As matter of fact, the treated etiolated hypocotyls was thicker than that of control. Furthermore, the etiolated hypocotyls would appear to be more sensitive to auxin in dark. Therefore, in the presence of light, the inhibition for the elongation of etiolated hypocotyls after the application of indoleacetic acid would reduce.

SUMMARY

Indoleacetic acid at various concentrations accelerates the elongation of green hypocotyls of bean seedlings in light but inhibits the elongation of etiolated hypocotyls in dark. The development of the primary leaf and first internode of both green and etiolated bean plant was checked by the application of indoleactic acid in spite of light conditions. The thickening of the hypocotyls was also occurred in the presence of indoleacetic acid, especially in case of etiolated hypocotyls. Dry weight per unit length of treated hypocotyls is greater than that of control. The effect of indoleacetic acid upon the elongation of green hypocotyls in dark and etiolated hypocotyls in light became less significant.

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ELONGATION OF WHEAT COLEOPTILE UNDER THE INFLUENCE OF MINOR ELEMENTS, INDOLE-3-ACETIC ACID AND OTHER CHEMICALS

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INTRODUCTION

Since 1942, we have published a series of papers dealing with the effect of minor elements, such as manganese and zinc, and indole-3-acetic acid on plant growth and carbohydrate metabolism (8, 9, 10, 12-17, 24, 25). The aim of these works is to throw light on the essential nature of these chemicals in plant life. Up to the present, results available in this laboratory are all in agreement in that the behavior of minor elements is quite different from that of indole-3-acetic acid both in plant growth and metabolism. The present work dealing with the elongation of wheat coleoptile constitutes a part of these studies. Coleoptile was chosen as material because it has been a favorite for demonstration of growth reaction to auxins. It is interesting to know whether the effect of minor elements on the elongation of coleoptile is the same or not as that of auxin. Manganese, zinc, boron and copper were used as the representatives of minor elements and indole-3-acetic acid as of auxins. Besides the chemicals mentioned above, colchicine, chloral hydrate and formaldehyde were also used in these experiments.

RESULTS

I. Intact Coleoptiles

MATERIAL AND METHOD. Wheat seeds (University of Nanking No. 2905) of uniform size were carefully selected. After rinsing in distilled water for one hour and drying with blotting paper, they were sterilized with 3% formaldehyde for 10 minutes. They were rinsed again with sterilized, distilled water three times, then were placed in sterilized Petri dishes for germination, each dish containing 100 grains of seeds and

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5 ml. of the aquaous solution of different reagents. The concentration of the reagents used in these experiments was as follows: Chloral hydrate and formaldehyde, 0.005-0.05%; copper sulphate, 10^{-6}— 10^{-10}M.; other reagents, 10^{-4}—10^{-8}M. Redistilled water were used as control throughout all these experiments.

When the coleoptile of the seedlings developed to 4-5 mm. in length, 20 seedlings of equal development were selected out from each dish and transplanted in 500 ml. beaker, containing 30 ml. of the same kind of reagent solution as in the germination dish. The seedlings were allowed to grow on glass wool, and between the wall of the beaker and a cylinder made of parchment paper whose diameter was a little smaller than that of the beaker. In such an outfit the seedlings grew straightly.

All apparatus used in these experiments, including the culture vessels, were sterilized three times in an autoclave under 15 pounds pressure.

The cultures were placed in an incubator of 20±5°C. Measurement was taken every 12 hours under red light.

1. Effect of manganese sulphate

Table 1 shows the results of elongation of the coleoptile in redistilled water and in manganese sulphate solutions of different concentrations during 60 hours. High concentration of manganese sulphate suppressed the growth of coleoptile at the first

TABLE 1. ELONGATION OF WHEAT COLEOPTILE (CM.) UNDER THE EFFECT OF MANGANESE SULPHATE. FIGURES ARE AVERAGE OF TWENTY SEEDLINGS.

Hours	Control	10^{-8}M.	10^{-7}M.	10^{-6}M.	10^{-5}M.	10^{-4}M.
12	0.8	0.9	1.0	1.1	0.6	0.5
24	2.2	2.2	2.5	2.8	1.8	1.5
36	3.5	3.6	4.0	4.1	3.1	2.9
48	4.7	4.9	5.0	5.1	4.6	4.6
60	5.2	5.4	5.5	5.5	5.2	5.2

two days. But the growth rate of coleoptile in these solutions became greater at the beginning of the second day so that ultimately the elongation of coleoptile grown in 10^{-4}M. and 10^{-5}M. solutions was as good as that of the control. Manganese sulphate in more dilute concentrations improved the growth of wheat coleoptile. The beneficial effect of manganese sulphate on root growth was also significant, though not being recorded.

3. Effect of zinc sulphate

Table 2 shows the effect of zinc sulphate on the elongation of wheat coleoptile. It is obvious from Table 2, in the presence of zinc sulphate, the growth of coleoptile was generally improved, especially at the first 12 hours, except in the solution of 10^{-4}M. where the elongation began to decrease at the third day. The results of this experiment is graphically shown in Fig. 1.

TABLE 2. ELONGATION OF WHEAT COLEOPTILE (CM.) UNDER THE EFFECT OF ZINC SULPHATE. FIGURES ARE AVERAGE OF TWENTY SEEDLINGS.

Hours	Control	10^{-8}M.	10^{-7}M.	10^{-6}M	10^{-5}M.	10^{-4}M.
12	1.2	1.4	1.5	1.4	1.5	1.4
24	2.7	3.3	3.4	3.2	3.7	3.3
36	3.8	4.1	4.4	4.2	4.3	4.1
48	4.7	5.1	5.2	5.1	5.1	4.9
60	5.4	5.8	5.8	5.6	5.7	5.3
72	5.8	6.0	6.0	6.0	5.9	5.6

3. Effect of boric acid

Unlike the sulphates of zinc and manganese, boric acid exerted no significant effect on the growth of wheat coleoptile at the first 36 hours, as may be seen from Table 3. Yet at the end of the experiment, elongation of the coleoptiles was greater in the solution of boric acid, regardless of concentration. High concentration of 10^{-4}M. and 10^{-5}M. more or less suppressed the growth at the first 24 hours.

TABLE 3. ELONGATION OF WHEAT COLEOPTILE (CM.) UNDER THE EFFECT OF BORIC ACID. FIGURES ARE AVERAGE OF TWENTY SEEDLINGS.

Hours	Control	10^{-8}M.	10^{-7}M.	10^{-6}M.	10^{-5}M.	10^{-4}M.
12	1.1	1.2	1.2	1.1	1.1	1.0
24	2.3	2.3	2.3	2.3	2.2	2.1
36	3.4	3.7	3.7	3.8	3.5	3.5
48	4.6	4.9	4.8	5.0	4.8	4.9
60	5.0	5.3	5.2	5.4	5.4	5.5

4. Effect of copper sulphate

The growth of wheat coleoptile in copper sulphate solution was inferior to the control at the beginning of the experiment, the greater the concentration of the copper sulphate, the more conspicuous this inhibiting effect. But the treated coleoptiles grew faster after 48 hours in culture, especially in more dilute solutions, so that the final length of coleoptile in the 10^{-10}M. and 10^{-9}M. solutions became a little greater than that of the control. Nevertheless, the length of coleoptiles grown in more concentrate solutions was all inferior to the control. The results of this experiment are shown in Table 4 and illustrated in Fig. 2.

TABLE 4. ELONGATION OF WHEAT COLEOPTILE (CM.) UNDER THE EFFECT OF COPPER SULPHATE. FIGURES ARE AVERAGE OF TWENTY SEEDLINGS.

Hours	Control	10^{-10}M.	10^{-9}M.	10^{-8}M.	10^{-7}M.	10^{-6}M.
12	2.6	1.5	1.1	0.8	1.0	0.7
24	4.0	2.7	2.2	1.6	1.9	1.3
36	5.5	4.2	3.7	2.9	3.2	2.3
48	6.1	5.5	5.1	4.3	4.3	4.4
60	6.2	6.3	6.1	5.2	5.5	4.8
72	6.2	6.5	6.5	5.9	5.9	5.6

5. Effect of Indole-3-acetic acid

It is obvious from Table 5 and Fig. 3, the results of this experiment were more or less similar with those of the foregoing experiment in that indole-3-acetic acid suppressed the elongation of wheat coleoptile at first but promoted its growth at the later period of the experiment. The coleoptile grown in the auxin solutions elongated very slowly during first 48 hours as compared with the control. After 48 hours, the treated coleoptiles began to elongate faster, particularly in the concentrate solutions. The total length of the coleoptile grown in the auxin solutions, however, was less than that of control.

TABLE 5. ELONGATION OF WHEAT COLEOPTILE (CM.) UNDER THE EFFECT OF INDLE-3-ACETIC ACID. FIGURES ARE AVERAGE OF TWENTY SEEDLINGS.

Hours	Control	10^{-8}M.	10^{-7}M.	10^{-6}M.	10^{-5}M.	10^{-4}M.
12	2.0	1.8	1.8	1.9	1.9	1.9
24	3.5	3.3	3.4	3.4	3.1	3.0
36	5.0	4.6	4.6	4.8	4.4	4.1
48	5.7	5.4	5.6	5.6	5.4	5.0
60	6.0	5.7	6.0	5.9	6.0	5.9
72	6.2	5.7	6.1	5.9	6.1	6.1

6. Effect of colchicine

The effect of colchicine on the elongation of wheat coleoptile seemed to be very insignificant at first; the length of the treated coleoptile was shorter than or almost equal to that of the control. But after 48 hours, those grown in the concentrate colchicine solutions (10^{-4}—10^{-6}M.) elongated faster than the control and their total length became a little longer as may be seen from Table 6 and Fig. 4.

TABLE 6. ELONGATION OF WHEAT COLEOPTILE (CM.) UNDER THE EFFECT OF COLCHICINE. FIGURES ARE AVERAGE OF TWENTY SEEDLINGS.

Hours	Control	10^{-8}M.	10^{-7}M.	10^{-6}M.	10^{-5}M.	10^{-4}M.
12	1.6	1.6	1.6	1.4	1.7	1.6
24	3.1	3.0	2.8	2.8	3.1	3.0
36	4.6	4.5	4.6	4.4	4.7	4.6
48	5.7	5.4	5.4	5.8	5.5	5.3
60	5.9	5.9	5.9	6.1	6.2	6.1
72	5.9	5.9	5.9	6.2	6.5	6.1

7. Effect of chloral hydrate

Chloral hydrate of 0.005% solution exerted no significant effect whatever on the growth of wheat coleoptile. Coleoptiles grown in the chloral hydrate solution with a concentration between 0.001-0.01% appeared to be a little longer than the control, especially in the later stage of growth. Higher concentration of 0.05% suppressed the elongation of wheat coleoptile from the start to the end. The results of this experiment are shown in Table 7 and Fig. 5.

TABLE 7. ELONGATION OF WHEAT COLEOPTILE (CM.) UNDER THE EFFECT OF CHLORAL HYDRATE. FIGURES ARE AVERAGE OF TWENTY SEEDLINGS.

Hours	Control	0.0005%	0.001%	0.005%	0.01%	0.05%
12	1.4	1.1	1.3	1.3	1.2	0.7
24	2.0	2.0	2.4	2.0	1.9	1.2
36	3.4	3.4	4.1	3.6	3.5	2.2
48	4.6	4.6	5.2	4.9	4.8	3.3
60	5.2	5.1	5.7	5.5	5.6	4.4
72	5.2	—	5.8	5.7	5.9	5.0
84	5.7	5.9	6.3	6.0	6.1	5.5

8. Effect of formaldehyde

In the first 24 hours, coleoptiles grown in the formaldehyde solutions whose concentration varied from 0.005 to 0.0005% respectively elongated somewhat faster than those of the control, yet their total length appeared to be of no difference between the treated and the controlled ones. On the contrary, growth of wheat coleoptile in the 0.01% solution was at first inferior to, but finally became equal to the control. High concentration of 0.05% inhibited the elongation of wheat coleoptile considerably. The results of this experiment are tabulated in Table 8.

TABLE 8. ELONGATION OF WHEAT COLEOPTILE (CM.) UNDER THE EFFECT OF FORMALDEHYDE. FIGURES ARE AVERAGE OF TWENTY SEEDLINGS.

Hours	Control	0.0005%	0.001%	0.005%	0.01%	0.05%
12	1.0	1.1	1.1	1.1	0.8	0.4
24	2.2	2.5	2.4	2.5	2.3	0.6
36	3.7	4.1	3.8	3.6	2.7	0.7
48	5.1	5.5	5.2	5.2	3.9	1.0
60	6.4	6.5	5.8	6.4	5.6	1.2
72	6.4	—	6.7	6.7	6.1	1.5
84	7.2	7.1	7.0	7.4	7.2	1.9

The data presented in the above tables reveal the fact that manganese, zinc and boron were really beneficial and essential to the growth of wheat coleoptile. Copper, on the other hand, under present experimental conditions, inhibited growth from the start to the end. Indole-3-acetic acid behaved like copper. Large dosage of colchicine stimulated growth in the later stage while small dosage proved to be indifferent. Chloral hydrate and formaldehyde in dilute concentration had no noticeable effect, but they arrested elongation in high concentration. Among minor elements which showed beneficial influence, the effect of boron seems to be different from that of manganese and zinc: the former did not manifest itself till the later stage of culture while the latter two could be recognized at the beginning of tranplantation. High concentration of manganese and zinc was growth inhibiting, but in the case of boron growth took place very satisfactorily even in the 10^{-4}M. solution.

Coleoptile is an organ of limited growth. Under room temperature and other favorable conditions, it reaches its final length of 6-7 cm. within 3½ days. Unless its

Fig. 1

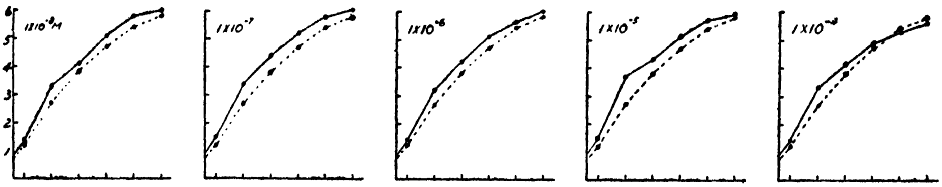


Fig. 2

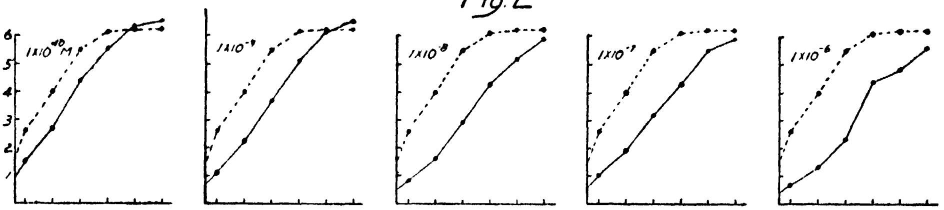


Fig. 3

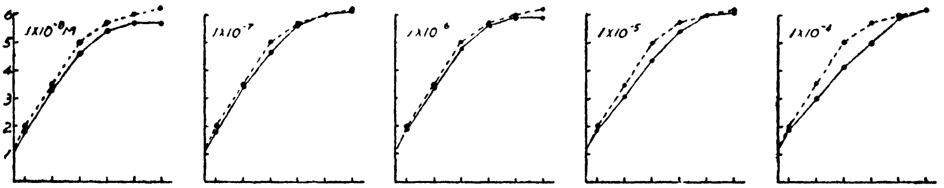


Fig. 4

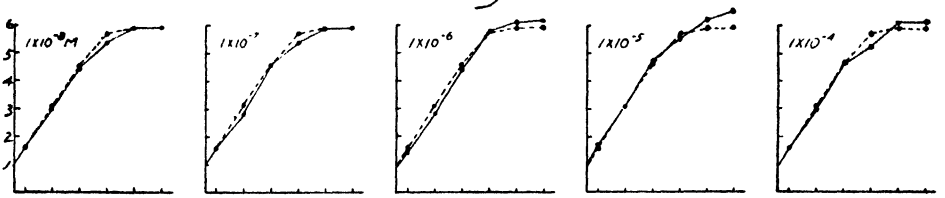
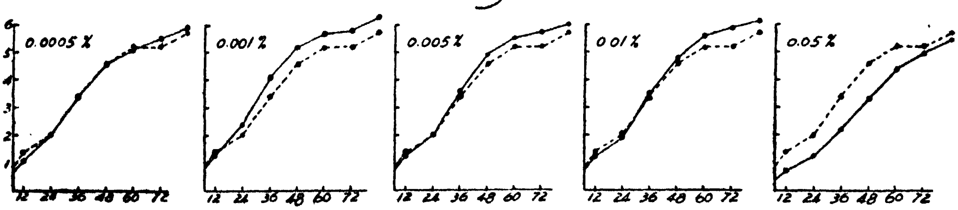


Fig. 5



Figs. 1-5. Growth curves of wheat coleoptile grown in the chemical solutions of different concentrations: Fig. 1, zinc sulphate; Fig. 2, copper sulphate; Fig. 3, indole-3-acetic acid; Fig. 4, colchicine; Fig. 5, chloral hydrate. Ordinate, length of coleoptile in cm.; abscissa, time in hours.

growth were arrested such as in the case of 0.05% formaldehyde, it elongates to the final length sooner or later. In case of growth promotion, the growth rate will be greater in the beginning or throughout the whole growth period than that of the control. Whenever the elongation of coleoptile is checked by some unfavorable condition, their growth rate would appear to be faster in the later period as a compensation of the slow growth at the beginning than that occurred in a more favorable condition. This was the case when the wheat coleoptiles grew under the influence of auxin, colchicine, copper sulphate and chloral hydrate. It is questionable, therefore, whether such superior growth over control in the later period could be regarded as a phenomenon of growth promotion or only a natural consequence of inferior growth at the beginning. It is noteworthy to note that the growth rate of the later period in such cases was never greater than that of the first period, though it was so when compared with that of the control in the same period.

II. Decapitated Coleoptiles

METHOD. In order to exclude the effect of growth promoting material which occur in the tip of coleoptile and may interfere with that of the chemical applied, the wheat coleoptiles used in the following experiments were decaptitated as follows. Wheat seeds were set for germination in Petri dishes as described in the first section. When the fibrous roots reached 4-5 mm. in length, they were planted in the purified sawdust in vial, one seed each. The seed was planted at an angle of 45° so that the coleoptile might develop straightly and perpendicularly. After the coleoptile developed to 2-3 cm. long, strictly straight ones were selected and decapitated, in the first time 1 mm. from the tip and in the second time (2 hours later after the first decapitation) 2 mm. from the cut surface. The length of the decapitated coleoptile was carefully measured. On the cut surface of the decapitated coleoptile chemicals in lanolin paste (0.2%) were smeared, with pure lanolin as the control. The decapitated coleoptiles were allowed to grow in an incubator whose relative humidity was kept at 90%. Measurements were taken once every 2 hours during 24 hours. Since it is difficult to make the initial length of the decapitated coleoptile exactly equal, there is possibility of greater elongation in case of longer pieces than in the case of shorter ones. To make up the difference, percentage increase in length against the initial measurement was taken as a criterion in the comparison of elongation.

Experiment with manganese sulphate, zinc sulphate, boric acid, copper sulphate and indole-3-acetic acid

The results of this experiment are shown in Table 9 and Fig. 6.

Manganese sulphate in lanolin promoted significantly the elongation of the decapitated coleoptiles, especially during 12-14th hour. For example: the growth rate per hour of the control at 12th hour was 0.34 mm. while that of the treated was 0.59 mm., 1.5 times that of the control. The growth rate per hour of the control at 14th hour was 0.37 mm., but that of the treated was 0.72 mm., almost 2 times that of the control. At the end of 24 hours, percentage increase in length of the treated coleoptiles was 13.3% greater than that of the control.

Not less significant was the effect of boric acid upon the elongation of the decapitated wheat coleoptile. The percentage increase in length at the end of the experiment was 41.7%, 11.3% greater than the control. Zinc sulphate in lanolin also exerted beneficial influence on the elongation of the decapitated coleoptile. Its effect was good in the first 6 hours as compared with that of manganese, thenceforth, the coleoptiles elongated less rapidly under of zinc than they did under the effect of manganese, though percentage increase in length in the case of the former was still greater than that of the control.

TABLE 9. INCREASE IN LENGTH (MM.) OF THE DECAPITATED COLEOPTILE AFTER APPLICATION OF 0.2% CHEMICAL IN LANOLIN. NUMBER OF COLEOPTILES: CONTROL, 19; MANGANESE SULPHATE, 16; ZINC SULPHATE, 18; BORIC ACID, 19; COPPER SULPHATE, 17; AND INDOLE-3-ACETIC ACID, 14. AVERAGE INITIAL LENGTH: CONTROL, 21.8; MANGANESE SULPHATE, 23.2; ZINC SULPHATE, 23.4; BORIC ACID, 22.3; COPPER SULPHATE, 19.1; AND INDOLE-3-ACETIC ACID, 19.2. TEMPERATURE: 19-21°C. RELATIVE HUMIDITY: 90%.

Hours	Control		Manganese sulphate		Zinc sulphate		Boric acid		Copper sulphate		Indoleacetic acid	
	mm.	%	mm.	%	mm.	%	mm.	%	mm.	%	mm.	%
2	0.1	0.5	0.4	1.8	0.6	2.7	0.7	3.0	0.25	1.3	0.3	1.6
4	0.8	3.6	1.2	5.0	1.6	7.0	1.5	6.9	0.66	3.5	1.1	5.6
6	1.3	6.0	2.3	9.9	2.4	10.3	3.0	13.3	1.0	5.3	1.9	10.00
8	1.9	9.0	3.3	14.3	3.1	13.1	3.6	16.1	1.5	7.6	2.6	13.7
10	2.7	12.3	4.4	19.1	4.2	18.1	4.5	20.4	2.0	10.6	3.4	17.8
12	3.5	15.9	5.6	24.2	4.9	21.0	5.5	24.9	2.5	12 9	4.1	21.3
14	4.2	19.3	7.0	30.4	5.5	23.3	6.4	28.9	3.0	15.8	4.8	25.2
16	5.2	24.1	7.9	34.2	6.6	28.3	7.3	32.9	3.3	17.5	5.5	28.6
18	5.9	27.1	9.0	38.8	7.2	30.9	8.1	36.5	3.7	19.2	5.9	30.8
20	6.1	28.0	9.4	40.7	7.8	33.3	8.6	38.5	3.8	20.1	6.7	35.0
22	6.4	29.2	9.7	4.20	8.1	34.7	9.0	40.3	4.0	21.1	7.2	37.8
24	6.6	30.4	10.1	43.6	8.4	35.9	9.3	41.7	4.1	21.7	7.6	39.4

The inhibiting effect of copper sulphate came into evidence as early as in the 4th hour and became prominent thenceforth. At the end of the experiment, the percentage increase in length was 8.7% less than that of the control.

Indole-3-acetic acid in lanolin promoted the elongation of the decapitated coleoptile from the very beginning and remained to be beneficial throughout the experiment. Indeed, its effect was not so remarkable as that of manganese and boron, yet it was certainly better than that of zinc.

2. Experiment with colchicine and chloral hydrate

The results of the experiment with 0.2% colchicine and chloral hydrate in lanolin paste are tabulated in Table 10 and illustrated in Fig. 7. A concentration of 0.2%

Fig. 6

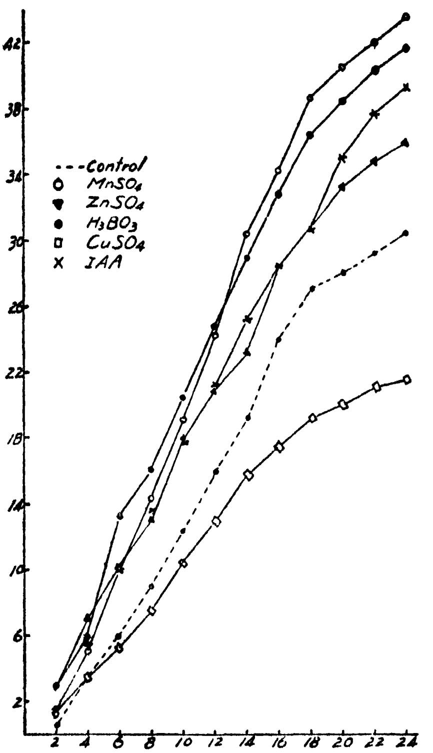


Fig. 7

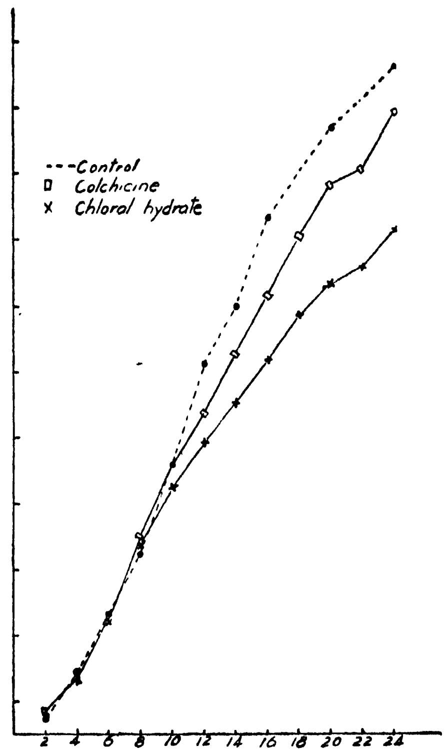


Fig. 6-7. Growth curves of decapitated coleoptile under the influence of chemicals in lanolin. Ordinate, percentage increase; abscissa, time in hours.

TABLE 10. INCREASE IN LENGTH (MM.) OF THE DECAPITATED COLEOPITE AFTER APPLICATION OF 0.2% CHEMICAL IN LANOLIN. NUMBER OF COLEOPTILES: CONTROL, 16; COLCHICINE, 19; CHLORAL HYDRATE, 14. AVERAGE INITIAL LENGTH: CONTROL, 30.2; COLCHICINE, 29.4; AND CHLORAL HYDRATE, 34.1. TEMPERATURE 24-27°C. RELATIVE HUMIDITYS 90%.

Hours	Control		Colchicine		Chloral hydrate	
	mm.	%	mm.	%	mm.	%
2	0.2	0.7	0.4	1.4	0.3	0.9
4	1.1	3.7	1.0	3.4	1.1	3.2
6	2.2	7.3	2.1	7.1	2.3	6.8
8	3.3	10.9	3.6	12.1	3.9	11.4
10	5.0	16.4	4.8	16.3	5.1	15.0
12	6.1	22.5	5.8	19.6	6.1	17.8
14	7.9	26.0	6.8	23.1	6.9	20.1
16	9.5	31.3	7.9	26.7	7.8	22.8
18	10.3	34.2	8.9	30.2	8.7	25.4
20	11.1	36.8	9.8	33.4	9.3	27.3
22	11.7	38.7	10.1	34.3	9.7	28.3
24	12.3	40.6	10.2	37.8	10.5	30.7

seemed to be unfavorable for the elongation of the decapitated coleoptile. The inhibiting effect manifested itself sooner or later in a duration of 24 hours. In the case of colchicine, this inhibiting effect did not come into evidence till the 12th hour. Thenceforth, the elongation of coleoptile under the effect of colchicine was always less than the control. Chloral hydrate in lanolin effected the elongation of the decapitated coleoptile in the same but more obvious manner as did colchicine. The percentage increase in length against the initial at the end of 24 hours was 30.7% in the former and 37.8% in the latter as compared with 40.6% of the control.

The above data lead to the conclusion that by applying lanolin paste containing minor elements to the cut surface of the decapitated wheat coleoptile, manganese, zinc and boron accelerated the elongation of the coleoptile while copper suppressed it. The effect of indole-3-acetic acid in lanolin was beneficial for the elongation, even better than that of the zinc. This was a result different from that dealing with its effect on the intact coleoptile. Colchicine and chloral hydrate inhibited the elongation, more evidently than in the case of intact coleoptile. Perhaps, the high concentration of 0.2% may account for this result.

III. Decapitated and excised coleoptiles

The data of the above-mentioned experiments reveal the fact that the effect of a chemical upon the elongation of wheat coleoptile may be different according to different circumstances. Thus indole-3-acetic acid in lanolin exerted a different effect upon decapitated coleoptile from what its solution did on intact ones. The cause of this difference may involve the dosage of the chemical and the manner it penetrates into the tissue. It is interesting to see, therefore, how these chemicals effect the elongation of a tissue deprived of growth promoting material and being immersed directly in the chemical solution. The following experiments were designed for such a purpose.

The seeds were allowed to germinate and grow in an incubator in redistilled water according to the method described in the first section. When the coleoptiles reached 2.5-3.5 cm. in length, straight ones were selected and decapitated and excised fragments of 1.5-2.5 cm. were cut. One fragment was cut from each coleoptile. After washing with redistilled water and drying with blotting paper, 10-15 pieces of the excised coleoptile were placed in a Petri dish containing 30 ml. of a reagent solution. Elongation was allowed to take place in an incubator in the dark. Measurement of length were taken once every 4 hours during 24 hours under red light.

1. The effect of manganese sulphate, zinc sulphate, and boric acid in different concentrations

Without exception, coleoptile fragments elongated more rapidly in the solutions of manganese sulphate, zinc sulphate and boric acid within the concentration range of 10^{-4}—10^{-8}M. There was a general trend to elongate slowly at first in case of larger dosage, though the total increase of length during 24 hours was always greater than that of the control. The effect of smaller dosage seemed to be better to some extent than that of the large dosage. The data of this experiment are summarised in Table 11.

TABLE 11. INCREASE IN LENGTH (MM.) OF THE COLEOPTILE FRAGMENTS IMMERSED IN THE REDISTILLED WATER AND CHEMICAL SOLUTIONS OF DIFFERENT CONCENTRATION DURING 24 HOURS. THE FIGURES ARE THE AVERAGE OF 10-15 FRAGMENTS. INITIAL LENGTH: CONTROL, 18.8; MANGANESE SULPHATE, 18.8 FOR 10^{-4}, 10^{-5} AND 10^{-8}M., 18.7 FOR 10^{-6} AND 10^{-7}M.; ZINC SULPHATE, 18.6 FOR 10^{-4}M., 19.2 FOR 10^{-5}M., 18.8 FOR 10^{-6}M., 18.4 FOR 10^{-7}M., AND 18.5 FOR 10^{-8}M.; BORIC ACID, 19.0 FOR 10^{-4} AND 10^{-6}M., 19.3 FOR 10^{-5}M., AND 19.2 FOR 10^{-7} AND 10^{-8}M.

Hour	Control	Manganese sulphate					Zinc sulphate					Boric acid				
		10^{-8}M.	10^{-7}M.	10^{-6}M.	10^{-5}M.	10^{-4}M.	10^{-8}M.	10^{-7}M.	10^{-6}M.	10^{-5}M.	10^{-4}M.	10^{-8}M.	10^{-7}M.	10^{-6}M.	10^{-5}M.	10^{-4}M.
4	1.4	1.5	1.4	1.4	1.3	1.2	1.2	1.2	1.0	1.1	1.3	1.4	1.5	1.3	1.2	1.1
8	3.0	3.0	3.0	3.3	3.1	2.8	3.0	3.5	2.9	2.8	2.8	3.3	3.3	3.1	2.5	2.9
12	3.9	4.8	5.0	4.7	4.5	4.0	4.5	4.7	4.5	4.4	4.7	4.4	4.4	4.3	4.0	4.2
16	4.6	6.0	5.8	6.1	5.9	5.1	5.8	6.0	5.4	5.7	5.6	5.7	5.4	6.1	5.3	5.6
20	5.4	6.4	6.1	6.7	6.5	5.5	6.6	6.8	6.2	6.3	6.0	6.2	6.2	6.3	5.7	6.3
24	5.5	6.9	6.9	7.3	6.8	6.1	7.5	7.8	6.9	6.7	6.4	6.5	6.8	6.7	6.3	6.5

2. The effect of copper sulphate, indole-3-acetic acid, colchicine, chloral hydrate and formaldehyde in different concentrations

The coleoptile fragments grown in copper sulphate solutions of different concentration started its elongation later than those of the control. From the 10th hour on, they began to elongate faster. In the solution of the most dilute concentration, the total increase of length was a little greater than that of the control. The elongation of coleoptile grown in solutions of 10^{-7}—10^{-9}M. was almost equal to the control. Copper sulphate in concentration of 10^{-6}M. inhibited the elongation from the beginning to the end.

Indole-3-acetic acid with a concentration range of 10^{-4}—10^{-8}M. behaved similarly as copper sulphate. It inhibited the elongation of the excised coleoptile at a beginning, till the 20th hour, it promoted the growth significantly. The elongation of excised coleoptile in the solutions of 10^{-7} and 10^{-8}M. was more or less better than that of the control, while those in the solutions of 10^{-5} and 10^{-6}M. get the same total length as the control. Indole-3-acetic acid of 10^{-4}M. apparently inhibited the elongation from the beginning to the end, its effect was even more prominent than that of copper sulphate of 10^{-6}M.

Colchicine in a concentration of 10^{-8}M. promoted the elongation of coleoptile a little but larger dosage of colchicine was unfavorable to the elongation. On the other hand, the elongation of the excised coleoptile in the chloral hydrate solutions of all concentration was more or less improved except those in the most concentrate solution of 0.05%.

Within the concentration range used in the present experiment, formaldehyde was very toxic to the coleoptile. There was a little increase in length in the case of coleoptiles immersed in the solutions of 0.001-0.0005%, though the total length of the treated coleoptiles was far shorter than that of the control. As to the length of coleoptile immersed in the solutions with a dosage larger than 0.001%, there was a decrease

instead of increase. The tissues lost turgidity sooner or later according to the concentration was greater or smaller. At the same time, they shrank to some extent.

The results of this experiment are tabulated in Table 12.

TABLE 12. INCREASE IN LENGTH (MM.) OF THE COLEOPTILE FRAGMENTS IMMERSED IN REDISTILLED WATER AND CHEMICAL SOLUTIONS OF DIFFERENT CONCENTRATION DURING 24 HOURS. THE FIGURES ARE AVERAGE OF 10–15 FRAGMENTS. INITIAL LENGTH: CONTROLA 14.8; COPPER SULPHATE, 16.3 FOR 10^{-6}M., 17.6 FOR 10^{-7}M., 16.6 FOR 10^{-8}M., 15.6 FOR 10^{-9}M., AND 17.0 FOR 10^{-10}M.; INDOLE-3-ACETIC ACID, 17.5 FOR 10^{-4}M., 16.1 FOR 10^{-5}M., 15.6 FOR 10^{-6}M., 17.0 FOR 10^{-7}M., AND 15.4 FOR 10^{-8}M.; COLCHICINE, 14.9 FOR 10^{-4}M., 14.8 FOR 10^{-5}M., 15.4 FOR 10^{-6} AND 10^{-8}M., AND 15.1 FOR 10^{-7}M.; CHLORAL HYDRATE, 15.4 FOR 0.05%, 16.3 FOR 0.01%, 15.7 FOR 0.005%, 14.9 FOR 0.001% AND 16.7 FOR 0.0005%; FORMALDEHYDE, 23.4 FOR 0.05%, 24.9 FOR 0.01%, 24.6 FOR 0.005%, 24.5 FOR 0.001%, AND 25.3 FOR 0.0005%.

Hour	Control	Copper sulphate					Indole-3-acetic acid					Colchicine				
		10^{-10}M.	10^{-9}M.	10^{-8}M.	10^{-7}M.	10^{-6}M.	10^{-8}M.	10^{-7}M.	10^{-6}M.	10^{-5}M.	10^{-4}M.	10^{-8}M.	10^{-7}M.	10^{-6}M.	10^{-5}M.	10^{-4}M.
4	1.5	1.1	0.9	1.3	1.0	0.8	1.4	1.1	1.2	1.3	1.1	1.6	1.8	1.0	1.2	0.9
8	2.8	2.0	2.4	2.0	1.9	1.5	2.0	2.1	1.6	2.1	2.0	2.4	2.2	1.8	1.8	1.4
12	3.6	3.6	3.2	3.2	3.3	2.8	3.7	3.4	3.1	3.7	2.9	3.9	3.4	2.6	2.7	2.5
16	4.3	4.3	4.0	3.8	3.8	3.4	4.5	4.2	4.2	4.3	3.9	4.6	3.8	3.3	3.4	2.9
20	5.1	5.3	5.0	5.0	5.0	3.9	5.6	5.4	5.1	4.9	4.7	5.6	4.7	4.0	4.1	3.9
24	5.8	6.5	5.9	6.2	6.2	5.0	6.5	6.6	6.1	5.9	4.8	6.2	5.7	4.9	4.8	4.6

Hour	Chloral hydrate					Formaldehyde				
	0.0005%	0.001%	0.005%	0.01%	0.05%	0.0005%	0.001%	0.005%	0.01%	0.05%
4	1.3	1.1	1.1	1.0	0.9	1.3	1.1	1.5	0.1	0.4
8	2.5	3.1	1.9	1.4	1.6	1.8	1.5	1.2	-0.2	-0.5
12	4.0	3.4	3.5	3.3	2.9	2.2	1.9	1.0	-0.4	-1.0
16	4.4	4.0	4.4	4.2	3.4	2.7	2.1	0.6	-1.1	-1.3
20	6.2	4.9	5.2	5.0	4.1	2.7	2.1	0.1	-1.6	-1.8
24	7.1	5.9	6.1	6.3	4.8	2.7	2.4	0.0	-1.8	-1.8

Data of Table 11 and 12 show definitely the fact that excised coleoptile deprived of tip secured greater length during 24 hours in the solutions of manganese sulphate, zinc sulphate and boric acid than those in the redistilled water. Copper sulphate, indole-3-acetic acid, colchicine and chloral hydrate made similar or a slight increase in length than the control when their dosage was small but they definitely inhibited the elongation when the dosage was large. Formaldehyde, under the circumstances of this experiment, was toxic to the coleoptile.

DISCUSSION

In the present work, three kinds of material, namely; intact coleoptile, decapitated coleoptile and excised coleoptile, were allowed to elongate under three different conditions.

The intact coleoptiles were cultured with their root system immersing in the chemical solution. The effect of the chemical concerned upon the coleoptile is certainly indirect, because the response of the coleoptile may be a result either of promotion or retardation of root growth, or of the chemical which has been changed into other material while penetrating through the conducting tissue. Direct cultivation of decapitated and excised coleoptile in a chemical solution during a short duration would appear to be more suitable in securing reliable results. Application of chemical in lanolin paste to the decapitated coleoptile is also a direct method of showing the effect on the elongation. The weak point of this method consists in that the diffusion velocity of chemicals of different molecular size and other physico-chemical properties is always different. But by treating the different materials with different methods, it is possible to pry into the behavior of the chemicals in question and the response of plant to them.

No matter what kind of material was used and under whatever condition the materials were placed, manganese sulphate, zinc sulphate and boric acid exhibited themselves as promotors for the elongation of wheat coleoptile. This is meant that these minor elements are always beneficial for growth, directly or indirectly. These results are all in agreement with those of the works which have done in our laboratory during these ten years.

Copper sulphate retarded the elongation of coleoptile under any condition except when it is used in a very dilute concentration. 0.2% copper sulphate in lanolin proved to be toxic. This is apparently due to high dosage, because copper sulphate must have greater diffusibility than indole-3-acetic acid and colchicine. Lipmann and MacKinney (11) found that barley deficient of copper was unable to bear seed. Saeyer (18) found that the presence of copper at a concentration of 0.1 parts per billion improved the growth of *Sirodela polyrrhiza* but larger dosage was toxic. Above all, the essentiality of copper in minute quantity has been firmly established by the extensive studies of Stout and Arnon (23). It is the writers' believe that if a concentration weaker than 10^{-10}M. had been used, copper would have proved as effective as manganese, zinc and boron.

The effect of indole-3-acetic acid on the elongation of coleoptile or shoot are rather conflicting. There are many reports indicating the beneficial effect of indole-3-acetic acid on coleoptile elongation or top growth of the intact seedling [for example, Albaum, Kaiser and Eichel (1), Thimann and Lane (26), Eaton (5), Gross (7), Grace (6)]. But counter-evidences are also numerous[(1)]. The results of the present work indicate that indole-3-acetic acid in low concentration stimulated the elongation slightly but high concentration definitely suppressed it. This conclusion is quite in agreement with those of our earlier works [Loo (12), Loo and Tang (16)]. As to the effect of indole-3-acetic acid on the growth of decapitated or excised coleoptile, opinions are also divergent. Authors like Bonner (4), Avery and Sargent (3), Scheer (19), Schneider (20), and Thimann and Schneider (27) claim that indole-3-acetic acid promotes the elongation, that within certain range of concentration, rate of elongation is proportional to the concentration. But, on the other hand, Avery and LaRue (2) found that indole-3-acetic

(1). For literature see Loo and Tang (16).

acid within a concentration range of 1:100,000—1:5,000,000 retarded the elongation of excised oat coleoptile. The results of the present work show that in the case of growing excised and decapitated coleoptile in indole-3-acetic acid solutions, the total increase in length under small dosage was equal to or even slightly better than that of control, while larger dosage definitely checked their increase. In this point, the effect of indole-3-acetic acid was similar with those of colchicine and chloral hydrate. But indole-3-acetic acid in 0.2% lanolin paste stimulated straight growth of wheat coleoptile to some extent. Lack of auxin in the decapitated coleoptile may be a cause of this phenomenon, but from the manner of elongation of the decapitated and excised coleoptile in the auxin solutions, another cause may be considered. Perhaps, indole-3-acetic acid diffuses from lanolin paste to the plant tissue more slowly than colchicine and chloral hydrate and its actual concentration in the plant tissue may be very low so that it stimulates growth. We doubt whether indole-3-acetic acid is really essential to the elongation of coleoptile.

Many authors attribute the beneficial effect of minor elements on plant growth to their activation or production of auxin. For example, Skoong (22) believes that the effect of zinc on plant growth is indirect, its effectiveness arises from the activation of auxin or its precursor. Eaton (5) is of the same opinion as Skoog, he claims that the beneficial effect of boron on the growth of cotton seedlings consists in the production of auxin. C. Tsui (28) recently demonstrates a close relation between zinc deficiency and auxin content in tomato: free auxin and enzyme-digestible, bound auxin contents increase by supplying zinc to the zinc deficient plant. But the results of works done in this laboratory during the past ten years have shown clearly that the beneficial effect of manganese and zinc on seed germination and early growth of seedlings (Loo, 12), pollen germination and pollen tube growth (Loo and Huang, 13; Huang, 8) and especially on the metabolism of plant (King, 9, 10; Loo & Ni, 15; Ni, 17; Loo, Ni and Huang, 14) was quite different from that of indole-3-acetic acid. Moreover, if the effect of manganese or zinc on plant growth is no more than the activation or production of auxin, it would follow that the beneficial effect of these minor elements would never surpass that of auxin. The results of the present study and earlier works from this laboratory show that it is not the case. It is the writers' believe that the essentiality of minor elements to plant growth must be sought from their catalytic action in the metabolic reactions of plant and their effect on the colloidal state of protoplasm. Concerning the latter point, a recent paper on the rôle of minor elements in the increase of salt-resistance in plants by Shkolnik, Makarova and Styeklova (21) is of great interest. They enumerate the effect of minor elements in the follow-4 points as the causes of this increase: Minor elements (1) increase the organic osmotic substances in plant, (2) maintain the synthetic activity of plant under abnormal conditions, (3) prevent the penetration of salts, and (4) regulate abnormal colloidal state of the cell caused by high content of salts. This is certainly a promising road to the solution of this problem.

SUMMARY

1. Elongation of intact coleoptile, decapitated coleoptile and excised coleoptile of wheat was promoted by culturing the seedlings in the solutions of manganese sulphate, zinc sulphate and boric acid respectively or by applying lanolin paste containing these chemicals to the cut surface of the decapitated coleoptile. Copper sulphate suppressed the elongation of coleoptile, especially in lanolin paste.

2. The effect of indole-3-acetic acid solution of low concentration on the elongation was equal to or slightly better than that of redistilled water, large dosage inhibited elongation definitely. But indole-3-acetic acid in lanolin promoted the elongation of the decapitated coleoptile to some extent.

3. Colchicine and chloral hydrate behaved like the indole-3-acetic acid solution.

4. Formaldehyde of low concentration had no noticeable effect, but high concentration was very toxic.

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PRELIMINARY EXPERIMENT ON REDUCTASE IN SOYBEAN SPROUTS[1]

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It has been known for a number of years that there is a nitrogen-reducing enzyme-reductase in higher plants (1, 2, 3.). The nature of this enzyme, however, is still quite puzzling. Some writer (4) has shown that the boiled plant sap reduces nitrate as well as the unboiled and regarded the reduction being not an enzymatic activity. Attempts are, therefore, made to clarify the situation in plant tissues.

In the present work soybean sprouts were used as a source of the enzyme. Soybean sprouts, after the removal of the cotyledons, were washed and ground in a mortar. The expressed sap was collected and then filtered with the aid of suction to remove the debris of the cells. To 100 c.c. of the sap 35 grams of ammonium sulfate was added.

(1) This work was carried out at the Dept., of Botany, University of Peking, Peking.

The mixture was then allowed to stand over night at O°-5°C. The precipitate formed was filtered under suction and the filtrate discarded. The precipitated protein was redissolved in water and again precipitated by ammonium sulfate. It contains no nitrate or nitrite.

The activity of the preparation is measured by determining the amount of nitrite produced from the reduction of added nitrates. Colorimetric method was used for the detection of nitrite by employing sulfanilic acid and α-naphthylamine as described by Snell and Snell (5).

The partially purified enzyme from soybean sprouts was found to have a powerful reducing effect on nitrates. It is thermolabile and loses its reduction power in half a minute in boiling water. The optimal temperature of activity is about 40°C and the optimal pH-value is 5.2. Potassium cyanide was found to inhibit the activity of this enzyme while sodium fluoride, iodoacetic acid and carbon monoxide have no effect.

Upon standing about a week this precipitated protein loses its reducing power. Since a system can only be reduced at the expense of another system which is simultaneously oxidised, certain oxidizable substance originally present may be exhausted during a week-period of storage. It has been shown that in certain bacterial preparations, nitrate reduction was coupled with dehydrogenation of some organic acids (2). With this in mind, a few experiments have been made. Using Thunberg's method, lactic dehydrogenase was found to exist in the precipitated protein of soybean sprouts. And by adding lactate to the system, the nitrate reducing power of the stored protein reappeared. These results show that a coupled redox system exists in soybean.

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